POWER PLANT ENGINEERING

GENERATION, TRANSMISSION AND UTILIZATION OF STEAM, ELECTRIC, DIESEL AND HYDRAULIC POWER

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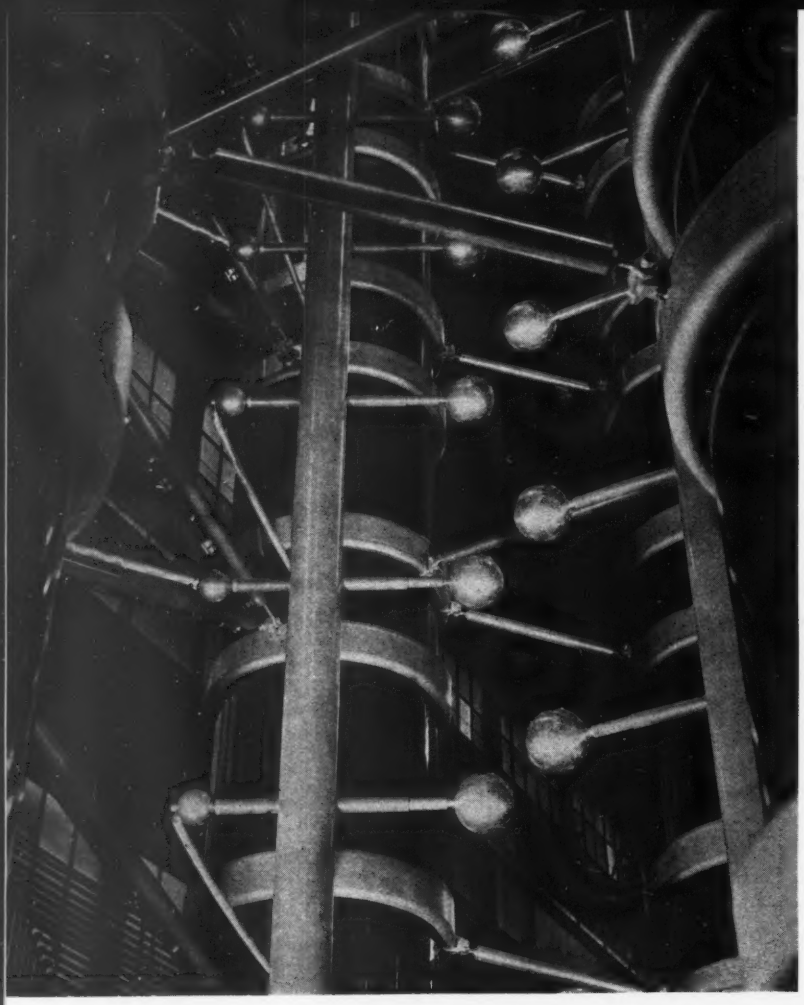

This curious array of rods, balls and cylinders is going to be one of the principal features of the General Electric Co.'s exhibit at the New York World's Fair this summer. Its performance in Steinmetz Hall, where it is to be installed, will thrill many thousands of visitors who never have had an opportunity to see equipment of this kind in action before.

High Potential Tinkertoys

SCIENCE gives rise to some strange looking gadgets. Here, for example, is one which resembles an overgrown Tinkertoy or a pawnbroker's nightmare, at best, something that originated in the brain of a Hollywood movie director in a moment of exotic abandon, whatever that is. Yet, we can assure you, it is none of these; actually, it is something very scientific. If you want to give it a fanciful name you might call it a potential step ladder or a step ladder for volts because, confidentially, that is what it is.

When Ben Franklin overstepped the bounds of colonial discretion (he was a lucky dog) and flew his kite in a thunder storm, he, probably, never dreamed that his action would, some day, lead to this outlandish array of rods and balls. Perhaps Ben should not be held accountable because, after all, he was only trying to establish a common relationship between lightning and electricity, and this he accomplished very well.

Ever since that time, however, men have been interested in the phenomenon of lightning and in recent years certain groups have actually succeeded in producing bolts of artificial lightning in the laboratory.

Foremost in this field is the group of engineers working in the lightning research laboratory of the General Electric Co. at Pittsfield, Mass. Gradually they have pushed the voltages higher; 2,400,000 in 1927; 3,600,000 in 1928; 5,000,000 in 1929 and finally 10,000,000 volts!

And that's what this is—a 10,000,000 volt lightning generator, the one to be installed in the General Electric exhibit at the New York World's Fair. This generator, a replica of those at Pittsfield in action only, bears little resemblance to its famous predecessors. It has been completely modernized and spectators at the Fair will be treated to one of the most unusual sights to be offered at the great exposition when its discharge crashes across the gap. The discharge jumps 30 ft., but that is probably less than the distance unsuspecting spectators will jump when the unit goes into action.

WITH THE EDITORS

Energy Resources and National Policy

ON JANUARY 28 the National Resources Committee submitted to President Roosevelt a report under the heading "Energy Resources and National Policy". This title parallels so closely the theme of the January 1939 issue of POWER PLANT ENGINEERING that the policies which the Committee recommends to the President demand editorial comment particularly in view of the fact that certain policies dealing with a phase of the problem were suggested in the pages of this magazine. Inasmuch as the report of the Committee was released for publication at a date too late to be presented in this March issue, item by item comparison is impossible at this time.

Obviously, as the Committee reports, the fields of remedy with respect to conservation of energy resources lie "(1) in promoting greater efficiency in the production of the fuel resources from the standpoint of recovery; (2) in promoting greater economy in the use of fuels; and (3) in placing a larger share of the energy burden on lower grade fuels and water power." All three of the fields represent problems in engineering, the second and third being almost completely in the power generating field. And what are the recommendations? Briefly stated without supporting data, here are some that are typical:

Oil and Gas—"We propose that a Federal oil conservation board or commission should be created within the appropriate Government department to administer the Federal interest in the oil and gas industry and to make necessary rules and regulations concerning the production of and commerce in oil and gas."

Coal—"Some form of Federal regulation of bituminous coal is clearly necessary. . . . Some means are required for effectively balancing production against requirements, whether by control of prices, by control of distribution, or by both."

Water Power—"Federal policy should, in general, embrace eventual merging of private water-power plants into the system covered by any basin plan."

Stimulation and support of both fundamental and applied research by the Federal Government was urged, also the organization of an advisory planning group was recommended.

Concluding paragraphs of the report contained the following significant statements: "It is difficult in the long run, therefore, to envisage a national coal policy or a national petroleum policy or a national water-power policy without also in time a national policy directed toward all these energy producers—that is, a national energy resources policy. Such a broader and integrated policy toward the problems of coal, petroleum, natural gas, and water power cannot be evolved overnight, for each of those problems is amazingly complex and in combination they represent more than a simple sum of problems.

"Despite the complexity of those problems, in the national interest we shall have to move in the direction of solutions. It is well to remember that the present and proposed regulatory measures which we have discussed are designed to promote the development of the energy resources industries along lines that will be consistent with the broad national interest. The problems of conservation which dictate these measures are not the result of passing emergencies. Rather, they are continuing problems, and if they cannot be solved by the regulatory approach then we may anticipate with some confidence that there will emerge an insistent and eventually irresistible demand for public ownership and control."

The complete report presents incontrovertible data supplied by various departments of the Government indicating the present energy resources, the problems of conservation and the status of the fuel industries. The volume is informative and few will question the need for a national policy tending to conserve our energy resources. Some of the recommendations, however, will meet with determined opposition not only in the passing of legislation but in the enforcement of laws, and it is extremely doubtful that laws based entirely upon altruistic principles will succeed in bringing about the results the committee desires they should accomplish.

Regulatory laws, to be successfully enforceable, must have the support of the vast majority of the people. They must be "sold" to the industries they regulate as the most desirable course to be followed. Industries will not thrive in a free country under regulation that does not offer reasonable amounts of personal gains to those we are regulating, be they capitalists, managers or laborers.

The report fails to give adequate consideration to two very important factors: conservation accomplished by a high consumer price level, and the profits derived from education in the efficient use of energy resources. Both of these have had great influence in reducing fuel requirements in power plants and should not be overlooked.

It is the thought of many that the answer to many of the conservation problem lies with the fuel consuming public through voluntary conformity to suggested economical practices rather than compelling laws. Public ownership of energy resources may prevent waste in recovery from the earth, but there is no evidence that publicly owned power plants excel in the efficient use of fuel.

Time is ripe for the entire engineering profession to crystallize its thoughts and desires on this subject of public policies and to work for legislation that will accomplish, in the most agreeable manner, the three purposes cited by the Committee. Coordinated work along this line may be done through the professional societies and the American Engineering Council.

Meeting The At

Fig. 1. Hammermill's Twin Stacks. Coal enters the building at grade level

FOR SEVERAL YEARS prior to 1935, the fact was readily apparent that Hammermill Paper Company would soon require additional steam and power generating capacity as well as replacement of some of the existing boilers. At that time steam was furnished at 150 lb. pressure from a house consisting of two Babcock & Wilcox long drum boilers totaling 840 boiler horsepower and three Erie City vertical boilers aggregating 2366 boiler horsepower. The B. & W. boilers were of cast iron header construction and dated back to 1907 and 1908. They were equipped with an economizer. The Erie City boilers were installed in 1909, 11 and 13 and were also served by an economizer. All boilers were fired by traveling grates. The B. & W. boilers were used chiefly for winter loads. This house was located in the manufacturing center of the plant where space was at a premium.

A second boiler house and power generating station had been built in 1917 on the shore of Lake Erie and only a short distance from the manufacturing plant proper. This plant consisted of four long drum B. & W. boilers of 509 hp. each operated at 250 lb. pressure which supplied steam for three 2000 kw. condensing turbine generators. Excess steam above electrical energy requirements was carried to the plant distribution system and reduced to 150 lb. These boilers were fired by natural draft chain grate stokers. In this location expansion was readily possible there being space on three sides for additional boilers and space within the existing turbine room for a fourth unit.

In anticipation of necessary replacements and expansion a very comprehensive study had been made in 1932. At that time it was felt that the necessarily large investment was unwarranted particularly in view of another factor which had made itself felt, namely, that of fuel. The standard fuel had been ¾ in. Pittsburgh district slack. Increasing plant demands made it difficult to carry loads and maintain efficiencies and recourse was had to sized coal in the 150 lb. house. We were able to improve both generating capacity and efficiencies very materially with the use of this fuel and conditions were relieved for a time. The "stoker" coal was not satisfactory in the generating station as it elevated the steam temperatures to where trouble was encountered in the turbines. The capacity increases were smaller and did not warrant necessary changes to permit the use of prepared coal.

Shortly after changing fuel, a drastic change was made in the method of cooking pulp. This change materially reduced the steam consumption per ton of pulp but at the same time greatly increased the capacity of the cooking equipment so the net result as far as steam demand was concerned, was no boon to the boiler house. Continual increases in production of both pulp and paper mill, and rapidly rising maintenance costs in the boiler house again brought the issue to a head.

In the winter of 1934-35 Stone & Webster Engineering Corp. was called in to make a survey of the plant, to formulate a broad general power plant expansion program for the future, and to specifically recommend what immediate step should be taken.

A vast amount of detailed data was available as the entire plant steam distribution system had been metered for several years and complete records carefully kept. These data when correlated with departmental production records made it possible to accurately predict the future steam requirements based on an expected pulp and paper future production.

Electrical power demand was handled in similar manner. Although the departmental metering program in this field was not so far advanced as in the case of the steam distribution system, it was still possible to segregate the major consuming processes and

Power Requirements Hammermill Paper Co.

By R. T. STERNBERG

Superintendent of Power
Hammermill Paper Co., Erie, Pa.

determine their requirements. This permitted prediction of future power requirements.

It was agreed that the two oldest boilers should be scrapped. Disposition of the balance of the equipment would be determined by the economics of equipment necessary to replace it.

The requirements being determined and the problem stated, it was thus possible to set up several tentative plans and determine both capital and operating costs. Consideration was given to expansion of the steam plant at 150 lb. pressure and the generating plant on the condensing cycle, as well as to the installation of a by product power plant topping the plant steam distribution system. A very fortunate steam and power balance made it possible to top the distribution system with a pressure comfortably in the industrial plant range even in consideration of the fact that the steam consumption curve showed a history of decreasing consumption per ton of product, whereas the curve of power consumption exhibited just the opposite characteristics. Consideration was also given in determining the topping pressure, to the strong possibility of replacing a 1500 hp. condensing steam engine with electric drive within a very few years. Incidently, this replacement is now in process of construction.

The economics of the various plans coupled with the strong feeling that the centrally located space would soon be required for manufacturing purposes led to the decision to install a topping plant with the boiler house, immediately adjacent to the 250 lb. plant and the turbine in the space then existing in the generating station. This layout permitted use of the existing coal bunker as well as many other features in connection with the old station and reduced the amount of new building space to a minimum. Partially offsetting these savings—an 18-in. steam line was necessary to conduct the steam from the exhaust of the back pressure turbine to a strategic point in the plant distribution system. It was also necessary to

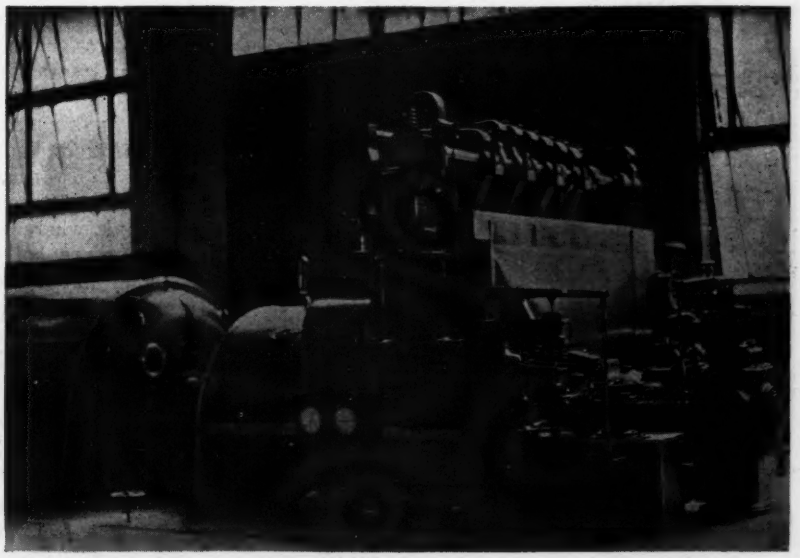

Fig. 2. The New Turbine. This unit is designed to operate with steam at initial conditions of 650 lb. per sq. in. and 750 deg. total temperature. It exhausts at a back pressure of 150 lb. per sq. in. and 450 deg. total temperature. The generator is a 5000 kw., 87.5 per cent power factor unit with a closed air cooling system

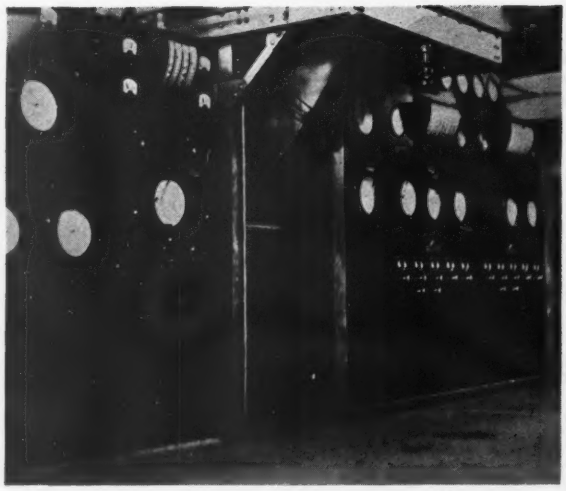

Fig. 3. Combustion control and instrument panels

install a new feedwater line from the main feed treatment plant to the new system.

The boiler plant addition decided on for immediate installation was the first half of what was considered to be ultimately required. It consisted of two B. & W. integral-furnace boilers with a design pressure of 725 lb. per sq. in. each designed to supply 80,000 lb. steam per hr. (continuous maximum) at a total temperature of 775 deg. F. Each boiler is fired by two B. & W. type B pulverizers, size 129. Each pulverizer is designed to be of sufficient size to carry the boiler at three-fourths of its nominal rating.

Each boiler is equipped with a Ljungstrom air heater and forced and induced draft fan with inlet vane control. The two fans for each unit are mounted on a common shaft driven by a single two speed motor. Full automatic combustion control was installed. Each boiler is equipped with a closed high pressure feedwater heater using steam from the exhaust of the main turbine. These heaters are designed for use chiefly in the summer months when the plant steam demand on occasion falls below full throttle flow of the main turbine.

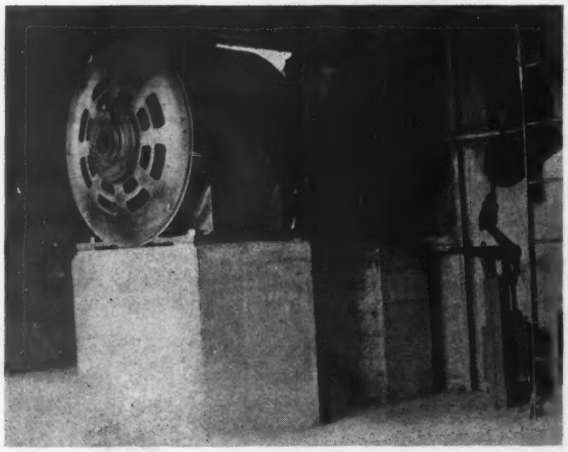

Fig. 4. Fan and Drive. Note control apparatus and inlet vanes on forced draft fans

Coal cars are run into the house on grade (the boiler house being located in a depression on the bank of Lake Erie) and the coal dropped through a bar screen into the main bunker. From the bunker each pulverizer is fed through spouting by automatically controlled intermittent spout feeder to a continuously operating crusher. From here it passes to a weighing scale and from these to the spout above the pulverizer table feeder. Two automatic devices are of note in this connection, as they are of local invention and have proved very satisfactory. One is located underneath the crusher and controls the spout feeder, stopping it when the coal above the weigh scale has built up to a point that further accumulation would clog the crusher, and starting it when the coal level has dropped to a predetermined point above the weigh scale. The other device is located below the weigh scale and above the pulverizer feeder table. It controls a warning light—normally out—but lighted when the level of the fuel above the pulverizer feeder has dropped to a predetermined level for any reason.

The pulverized coal burners are the B. & W. circular forced-draft type, and are equipped with oil torches for lighting off.

The original feedwater treatment system was an intermittent hot lime soda process. All condensate returns both clean and oily were gathered in a tank the level of which, combined with the demand, determined the amount of make-up. This necessitated frequent variation in treatment as the percentage of make-up varied. This system was satisfactory for the service up to this time, but was considered entirely inadequate in connection with the new installation. Dr. Sheppard T. Powell was retained to consult with Stone & Webster and ourselves on the question of feedwater treatment. It was decided to use the lime soda treatment plant to treat raw make-up exclusively. Water from this plant was supplied as 100 per cent feed to the lower pressure plants and to a new continuous primary phosphate treatment plant at the site of the new boiler house, where it represented make-up to the two 80,000 lb. boilers. The condensate returns were segregated from the original system and separately handled. Oily returns are first passed through an oil separator of our own design and after treatment with soda ash and iron sulphate passed to a sedimentation tank. From here the condensate is skimmed off and filtered through gravity type anthracite and magnetite filters into a controlled level tank. From here it is pumped to the condensate storage compartment of the primary phosphate treatment tank, where it gets first call as feed for the two high pressure boilers. The quantity of condensate available automatically determines the amount of treated make-up required from three pressure type anthracite and magnetite filters, deaerator and storage tank which follow the phosphate sedimentation tank.

Three boiler feed pumps are installed, one motor driven and two driven by 150 lb. pressure turbines exhausting to the softener. Any two pumps are capable of carrying the load. On its way to the pumps, the feedwater, now a mixture of condensate

Principal Equipment, Extension, Hammermill Paper Company

GENERAL

Company—Hammermill Paper Co.
Location—Erie, Pennsylvania.
Business—Pulp and Paper Manufacture.
Consulting Engineers and Constructors—Stone & Webster Engineering Corp.
Boiler Feedwater—Dr. Sheppard T. Powell.
Building and Equipment Foundations—H. Platt Construction Co.

BOILERS AND AUXILIARIES

Boilers—Two, Babcock & Wilcox Co.; integral furnace type, maximum capacity 80,000 lb. per hour each continuous; design pressure, 725 lb.; total temperature, 775 deg. F.
Superheaters—Babcock & Wilcox Co.
Water Columns— Diamond Power Specialty Co.
Soot Blowers—Diamond Power Specialty Co.
Boiler Brickwork—Geo. W. Allen Sons.
Breeching—Connery Construction Co.
Air Preheaters—One per boiler Ljungstrom regenerative horizontal type.
Stack—One radial brick, 250 ft. high M. W. Kellogg Co.

COMBUSTION EQUIPMENT

Burners—Four per boiler, Babcock & Wilcox Co.
Pulverized Coal Valves—Four per boiler, Babcock & Wilcox Co.
Coal Pulverizers—Two per boiler, Babcock & Wilcox Co., Type B.
Drives—Two per boiler, motor, General Electric Co.
Forced and Induced Draft Fans—One unit per boiler, consisting of one forced and one induced draft fan both with vane control mounted on common shaft supported on two bearings, B. F. Sturtevant Co.
Fan Drives—One per boiler, two speed motor, Burke Electric Co.
Combustion Control—Full automatic control pneumatic operation, Bailey Meter Co.

ASH HANDLING SYSTEM

Conveyor, Tank—Automatic Control Equipment—United Conveyors Corp.

COAL HANDLING

Spouting and Feeders—Stephens-Adamson Mfg. Co.
Coal Crushers and Tramp Iron Separators—Two per boiler, Pennsylvania Crusher Co.
Automatic Coal Scales—Two per boiler, Richardson Scale Co.

FEEDWATER SYSTEM

Feed Service Pumps—Three, Worthington Pump & Machinery Corp.
Drives—Three, 3600 r.p.m. Allis-Chalmers Mfg. Co.
Booster Pumps—Two, Worthington Pump & Machinery Corp.
Drives—Two motor, General Electric Co.
Sedimentation Tank—Cochrane Corp.
Pressure Filters—Three, Cochrane Corp., anthracite and magnetite.
Chemical Tanks and Proportioners—Cochrane Corp.
Feed Heater and Spray Type Deaerator—Cochrane Corp.
High Pressure Phosphate Pumps—Two, The Deming Co.
Sulphite Feeding Equipment—Cochrane Corp.
Boiler Feed Pumps—Three Worthington Pump & Machinery Corp., six stage type UX centrifugal 3600 r.p.m.
Drives—Two, Elliott Co. steam turbines, 150 lb. pres.; one motor, General Electric Co.
Feedwater Regulators and Excess Pressure Valves—One each per boiler, Northern Equipment Co.
Closed Feed Heaters—One per boiler, 150 lb. steam pressure, American Locomotive Co.
Oily Condensate Chemical Pumping, Feeding and Proportioning Equipment—Cochrane Corp.
Grease Extractor—Hammermill Paper Co. design, Erie Steel Construction Company.
Condensate Level Control—Bailey Meter Co.
Continuous Blowoff. Heat Exchanger—Cochrane Corp.
Continuous Blowoff. Flash Tank Level Control—The Swartwout Co.

TURBINE GENERATOR AND AUXILIARIES

Turbine Generator and Exciter—One 4000-kw. at 70 per cent P.F. 3600 r.p.m.; throttle conditions 650 lb. pressure, 750 deg. total temp.; exhaust, 150 lb., General Electric Co.
Generator Air Cooler—General Electric Co.
Oil Separator—The Sharples Specialty Co.
Generator Oil Circuit Breakers—General Electric Co.

MISCELLANEOUS

Station Service Switchgear—General Electric Co.
Station Service Transformers—Allis-Chalmers Mfg. Co.
Piping—Daugherty Co., Inc.
Pipe Covering and General Insulation—Ehret Magnesia Mfg. Co.
Desuperheater—Blaw-Knox Co.
Desuperheater Control—Bailey Meter Co.
"Apexior" Boiler Coating—Dampney Co. of America.

VALVES

Boiler and Superheater Safety — Consolidated Ashcroft Hancock Co.
Boiler Stop Check—The Edward Valve & Mfg. Co., Inc.
Boiler Feed Check—The Edward Valve & Mfg. Co., Inc.
Boiler Blowoff—Yarnall-Waring Co.
High Pressure Steam Gate—Chapman Valve Mfg. Co.
High Pressure Steam Globe—The Edward Valve & Mfg. Co., Chapman Valve Mfg. Co.
High Pressure Reducing Valves and Controls—Bailey Meter Co.
Turbine Exhaust Safety—Consolidated Ashcroft Hancock Co.
Atmospheric Relief—Atwood & Morrill Co.

INSTRUMENTS

Boiler Meters—Bailey Meter Co.
Steam Flow Meters—Bailey Meter Co.
Draft Gages—The Hays Corporation.
Recording Thermometers—Bailey Meter Co.; Brown Instrument Co.
Boiler Water Level Recorders—The Foxboro Company, Inc.
Feed Water Surge Tank Level Recorders—The Foxboro Company, Inc.
Indicating Thermometers—Taylor Instrument Cos.
Indicating Pressure Gages—Consolidated Ashcroft Hancock Co.
Water Flow Meters—Bailey Meter Co.
Coal Pulverizer Level Controls—Bailey Meter Co.

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and treated make-up is treated with sodium sulphite as a precautionary measure. (The boilers are apexiorized.) In addition to the primary phosphate treatment, supplementary phosphate is injected directly into the boilers. Hand control of a continuous blow down heat recovery system maintains the concentration at the proper point.

The turbine is designed to operate with steam at initial conditions of 650 lb. and 750 deg. total temperature. It exhausts at a back pressure of 150 lb. and 450 deg. temperature. The exhaust conditions were determined by the plant distribution system and services on it. The generator is 5000 kw. capacity at 87.5 per cent factor and is equipped with a closed air cooling system. The unit is equipped with a governor designed to permit its operation in partial compound with one of the existing condensing machines operating with 150 lb. throttle pressure when the plant steam demand on the turbine exhaust is incapable of generating the plant power demand in passing through the high pressure turbine only. The summer season creates this situation. This method of operation remains to be tried out, as some further piping changes are still to be made. So far the unit has been operated speed governed and the back pressure controlled by steam passing through a reducing station and desuperheater. These items are installed in sufficient size to care for the entire output of the two boilers in case of turbine outage.

The exhaust of the turbine or output of the desuperheater is carried to the plant system as previously mentioned by an 18 in. steam line. This line

Fig. 5. Exterior View of the boiler house addition

was installed in that size in anticipation of future developments to carry twice its present quantity.

The contract as engineers and constructors for this plant was let to Stone & Webster early in January, 1936, and the first commercial steam delivered to the mill on Sept. 16, 1936. The numerous tie-ins and connections necessary were made without a single interruption in service, a record all the more notable, as our own electrical construction forces were simultaneously installing an entire new switchroom and bus structure and the plant operating crews were entirely "green" on handling both high pressure equipment and pulverized coal.

Operation of the plant soon developed difficulties in connection with the boiler furnaces which were designed to burn coal of an ash fusion temperature of 2150 deg. as dry bottom jobs. Considerable slagging was encountered, making the ash difficult to handle and causing relatively rapid erosion of the refractory rear wall behind and between the cooling tubes, which were spaced on 10¾-in. centers. To correct this condition it was necessary to redesign the rear wall. A Bailey wall having smooth blocks was installed in one unit and equipped wth retractable soot blowers. The second unit was equipped with a bare tube wall with ⅛-in. clearance between tubes. This wall was also equipped with retractable blowers in spaces provided by columns of cast iron block covering wider tube spacing at the desired points. Each boiler was also equipped with a retractable blower in the side wall and one in the furnace roof. Both types of construction have worked out satisfactorily and minimized the earlier difficulties.

Several floor tubes in the furnace of one unit failed in service due to formation of steam pockets on the tops of the tubes. Complete new floors were installed in both units and the new tubes fitted with cores, which from observation to date have corrected the difficulty.

The original high pressure supplementary phosphate pumps failed and were replaced by the manufacturers with others of much better design. The replacements have given no trouble since their installation.

The high pressure reducing valves failed in interior detail after approximately a year's operation. Replacement of the affected parts was made in less than two days and to date the replacement seems to have corrected the difficulty.

Some difficulty has been experienced with seizing in two of the boiler feed pumps from undetermined causes. Several theories have been advanced and changes in design made accordingly which as yet have scarcely had time to either prove or disprove the theories.

One shutdown was experienced in the winter of 1937-38 caused possibly by regulation of frozen coal in the spouts after passing the bar grate over the main bunker. The pulp and paper mill was not in production at the time which permitted the outage of one boiler unit to cause the interruption (it being the only unit in service). Steps are being taken to house the open end of the coal shed to permit thawing of such cars as may be frozen in winter.

The operating results of the feedwater treating plant have been highly satisfactory. For the earlier months of operation it was necssary to run on a 100 per cent make-up basis, with the softener operated as a continuous lime soda unit and all phosphate fed directly to the boiler drums. At present the plant is operating as designed. At no time has there been any scale in the boiler, nor has it been necessary to use a turbine cleaner in them. As it seems at present, operation in summer, when condensate returns are at a minimum, will require opening of the boilers about every 60 working days for washing out the soft sludge that accumulates. During the winter, with a greater proportion of condensate in the feed, this will very likely be extended to 90 days and possibly longer.

The turbine was opened for inspection at the expiration of a year's service and found to be very clean and in generally good condition. The freedom of the interior of the turbine from any incrustation indicates the excellent steam conditions experienced. Boiler steam drums of larger diameter than standard were specified as well as oversize steam scrubbers. Control of water level has been satisfactory and free from difficulty. The performance of the feedwater treatment plant, previously noted together with the items already mentioned, have combined to produce steam of such quality that no difficulties due to solid content have been encountered.

Each manufacturer has stood fully behind his equipment and since the various difficulties have been ironed out, the plant, as a whole, has performed in a very satisfactory manner.

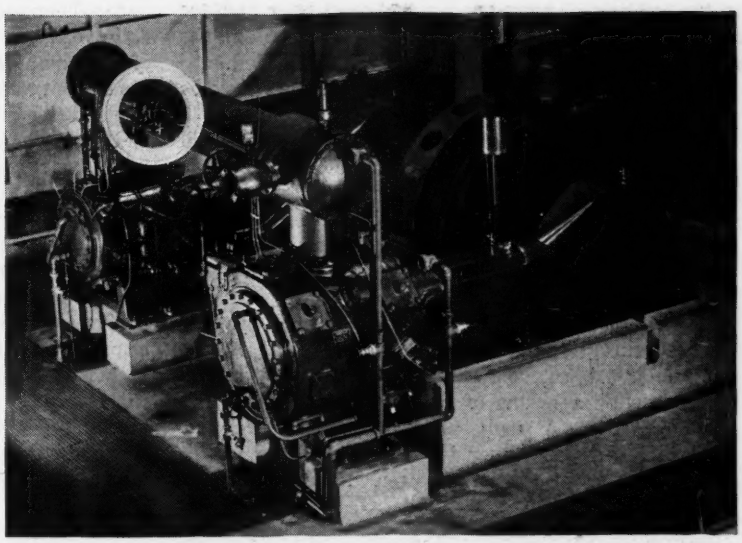


Fig. 1. Two stage compressor with the solenoid operated three way valves mounted on the intercooler and indicated by the white circle.* These valves, actuated electrically by contactors on the pressure responsive element shown in Fig. 2, control the air pressure used for opening the suction valves or clearance pockets in accordance with load. The pressure responsive element may be mounted at any convenient point. A panel arrangement with two governors is shown by Fig. 3

Multiple Compressor Control

New electro-pneumatic capacity control governor for constant speed compressors may be mounted remotely from the compressor and arranged to control one or a group of machines. Interlock, repositioning and plug-in features protect against voltage dips, give close pressure regulation and increased flexibility.

By E. M. PAULLIN

Assistant Manager, Compressor Division
Worthington Pump & Mach. Corp.
Buffalo, N. Y.

MOTOR DRIVEN COMPRESSORS of the medium and larger sizes are usually synchronous motor driven and run at a constant speed. In order to hold a uniform receiver pressure, however, it is necessary to vary the output of the compressor in proportion to the demand for air or gas on the system, and, since the speed of the unit cannot be varied the pumping rate of the compressor must be changed by unloading certain portions. It is common practice to use four equal unloading increments, thus permitting the compressor to operate at 100, 75, 50, 25, or 0 per cent capacity. This is usually spoken of as a five step control.

Actual unloading may be accomplished in different ways such as by: opening clearance pockets in the compressor cylinders; by holding open the suction valves so that the air or gas is drawn in and out of the cylinder without being compressed; or, by a combination of clearance pocket and suction valve unloading. The clearance pocket valves and the suction valve unloading elements are operated pneumatically and it becomes the function of the governor to admit or exhaust pressure from these elements in response to pressure changes in the system.

For this service the governor itself is a pressure, not speed, sensitive instrument. A number of different designs have been used in the past but the Worthington Class 50 governor is a comparatively recent development which offers numerous advantages over past practice. In its entirety it consists of a group of solenoid operated three way valves and a pressure sensitive governor instrument. The solenoid valves are mounted in any convenient location on the compressor, as for instance on the intercooler as shown by Fig. 1. These valves are actuated electrically by contactors from the pressure sensitive instrument and are energized or deenergized in definite sequence as the instrument responds to changes in the pressure system. They control the air pressure used to operate the unloading elements

*The duplex compressor five step control described in the text uses four solenoids which unload the machine by holding the suction valves open. Note that the two stage machine above has only three solenoids for a five step control. Low and high pressure cylinders are unloaded in parallel. Provision is made to hold the suction valves in each end of each cylinder open and in addition the crank end of each cylinder is provided with a clearance pocket. Opening the clearance pocket gives 75 per cent capacity while holding open the suction valves in the same end reduces the capacity to 50 per cent. For 25 per cent suction valves in the end opposite the clearance pockets are opened and the suction valves on the same end as the clearance pocket are closed with the clearance pocket itself left open. Opening the suction valve at the clearance pocket end then gives 0 capacity.

in the compressor cylinders as explained later and are arranged so that, when the contactors are open and the solenoids deenergized, the compressor is unloaded.

The governor instrument shown by Fig. 2 may be mounted at any convenient location near to or remote from the compressor and the design permits flush mounting directly on a panel either alone or with a group of gages and controllers. The system pressure is piped to the pressure sensitive diaphragm incorporated in the instrument. One panel arrangement is shown by Fig. 3, while Fig. 2 is a close up of the governor instrument with the cover opened.

Here one may observe the cam operated contacts which deenergize and energize the solenoids at the compressor. A ratchet wheel and a pair of ratchet pawls provide a means of rotating the cam shaft in either direction. A small gear-in-head instrument motor, which runs continuously while the instrument is in use, provides the motive power. Pressure changes on the diaphragm, transmitted through a linkage, engage one ratchet pawl when the upper pressure limit is reached and the other pawl at the lower pressure limit. Engaging one of the pawls allows the motive power to ratchet the cam shaft one position. The shape and position of the cams on this shaft will open or close one or more contacts in accordance with the unloading or loading sequence of the compressor.

Let us consider a two cylinder double acting single stage compressor. We will have four cylinder ends doing the work of compression at full load. If the suction valves are held open on one cylinder end, only three cylinder ends will be compressing and the capacity will be reduced to 75 per cent. Holding the suction valves open on two cylinder ends will give 50 per cent capacity and so on until all the suction valves are held open. Then even though the compressor is running at full speed, air or gas will be drawn in and forced out of the compressor cylinders without compression and the capacity of the compressor will be 0 per cent. Four solenoid valves will be required for this operating cycle and each solenoid will be wired to a contact in the governor instrument.

With the instrument in the 100 per cent load position all contacts will be closed and all solenoids energized. Pressure will be exhausted from the suction valve unloading elements, suction valves will be functioning normally and the compressor working at full capacity. When the pressure in the receiver reaches the upper limit, the governor instrument will move to the 75 per cent position, thus opening one contact and deenergizing one solenoid valve. This will instantly reduce the pumping rate of the compressor to 75 per cent. If this reduction in compressor capacity does not allow the receiver pressure to return to normal, or, if it still continues to increase, the governor instrument will act again and, by opening a second contact deenergizing a second solenoid valve, will reduce the pumping rate to 50 per cent. On the other hand, if the receiver pressure falls to the lower limit, the instrument will reverse its action reclosing in sequence the open contacts and reenergizing the solenoid valves. At zero capacity all contacts in the governor instrument are open and all solenoids are deenergized.

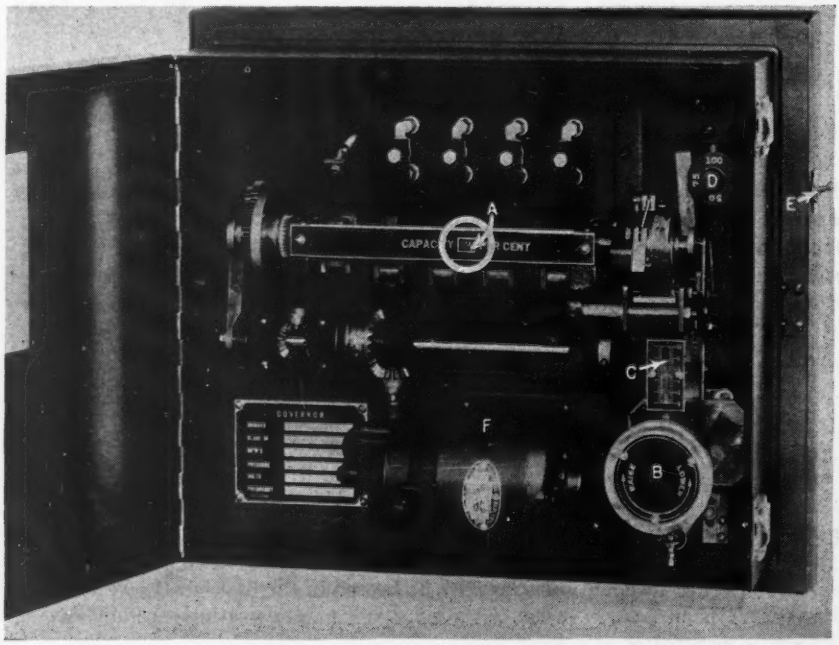


Fig. 2. Close up of the governor instrument. The capacity at which the instrument is operating at any moment is indicated at a A and is always visible through a window in the cover of the case. The pressure sensitive diaphragm is located behind the handwheel B. This diaphragm may be spring loaded by means of the handwheel in order to raise or lower the mean operating pressure and the adjustment so made is indicated on scale C. The pressure differential between minimum and maximum pressures may be changed by means of a thumb screw back of scale C but not visible in the photograph. D may be set to limit output of the compressor to any desired maximum and switch E may be used to stop the motor and lock the contactors at any desired compressor capacity. When this is done the compressor is loaded and unloaded in one step by the pressure switch shown in Fig. 5. The above instrument is usually mounted on a panel with a pressure gage and plug-in box shown by Fig. 3

Interlocks and Repositioning Features.

It becomes a simple matter to interlock the solenoid valve circuits with the motor starter so that regardless of the position of the governor instrument all solenoids will be deenergized during starting and stopping periods. With a synchronous motor starter the interlock-

ing is with the field circuit and with automatic field control the compressor will load only when the motor is synchronized and able to carry the load. This feature becomes valuable in localities subject to momentary voltage dips which might stall a synchronous motor if the load were not instantly removed. Compressors so equipped will momentarily drop their load, the motors will resynchronize and the compressor reload without the attention of an operator.

Another unique and outstanding feature of the Class 50 Governor is the repositioning of the pressure element mechanism after each governor operation. This means that each successive step in capacity reduction is made at precisely the same pressure. Having selected two pressures, say an upper limit of 100 lb. per sq. in. and a lower limit of 98 lb. and set the governor for these limits, the compressor will always work between the lower and the upper limit regardless of the per cent capacity at which the compressor is pumping.

Repositioning

The repositioning feature is more easily explained by reference to the record chart from a pressure recorder as reproduced in Fig. 4. The chart shows a twenty-four hour run in an industrial plant during which time the air capacity requirements were quite varied. Nevertheless, the pressure variation in the system was not beyond the upper and lower limits of the governor setting.

With previous Worthington governors, a definite change in pressure was required to operate each successive capacity position and the compressor unloaded as the pressure was built up, reloaded as the pressure fell. With the pressure steps pyramiding, high pressure was associated with reduced capacity and a lower pressure with full capacity. Obviously, it was necessary to adjust the governor so that its lowest pressure gave at least the minimum pressure requirement, so during periods of lighter demands the compressor was delivering air against a higher pressure than was actually required. With the Class 50 Governor repositioning the pressure elements after each successive operation, the governor always holds the pressure between the set upper and lower limits, resulting in partial capacity operation at reduced horsepower.

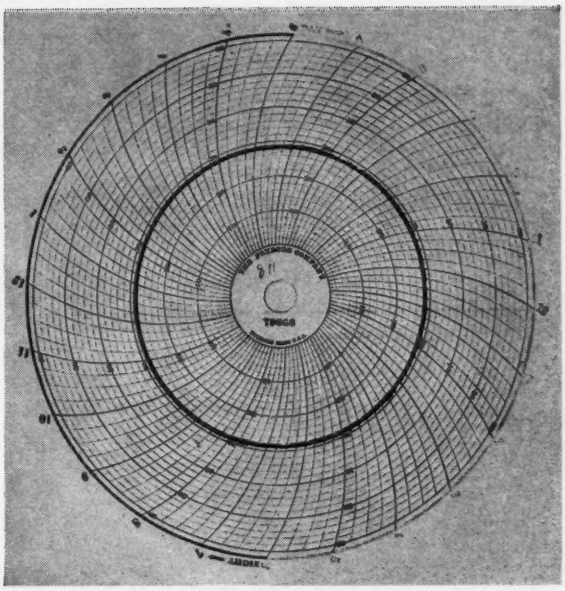


Fig. 4. Twenty-four hour chart showing the constant pressure maintained by the Class 50 governor in an industrial plant with a widely fluctuating air demand

The term "multiple compressor control" has grown out of the use of one or more Class 50 Governor instruments mounted on a control panel with a plugging system arranged to control several compressors. A typical installation of a two-governor panel, designed to control three compressors (two new and one existing) is shown in Fig. 3 and schematically in Fig. 5. The addition of a pressure recorder provides a visible and permanent record of pressure.

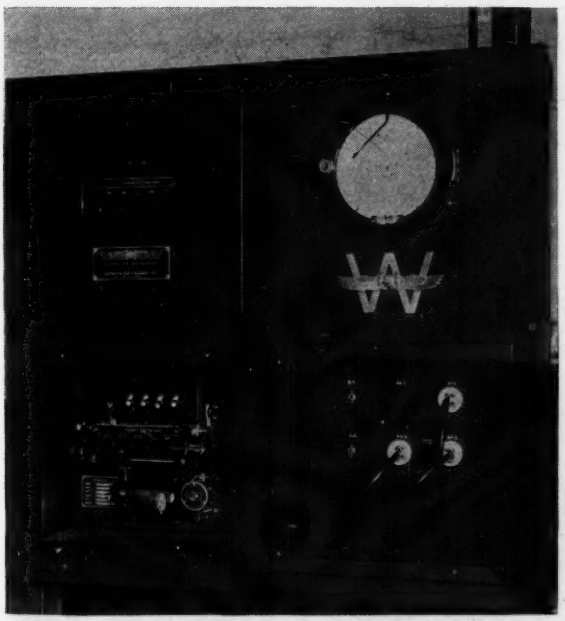


Fig. 3. Two instruments mounted on a panel with a pressure recorder and plug-in receptacles. A combination of this kind with two governors and three compressors is shown diagrammatically in Fig. 5

Plugging Sequence

With this arrangement the solenoid valves mounted on the compressors are not wired permanently to the contacts in the governor instrument, but are carried to polarized plugs which may be quickly plugged into sockets carrying power from the contacts in the governor instruments. Two sockets may be provided for the same governor instrument, making it possible to plug two compressors on the same governor. These two machines then load and unload in parallel as though they were one compressor of larger capacity.

A separate pressure switch adjusted to open its contacts at a pressure slightly above the setting of each Class 50 Governor instrument may be wired to an additional socket. When the solenoids from a compressor are plugged to that particular socket they will all become energized causing the compressor to operate fully loaded until the pressure switch setting has been reached. It is customary to provide one such pressure

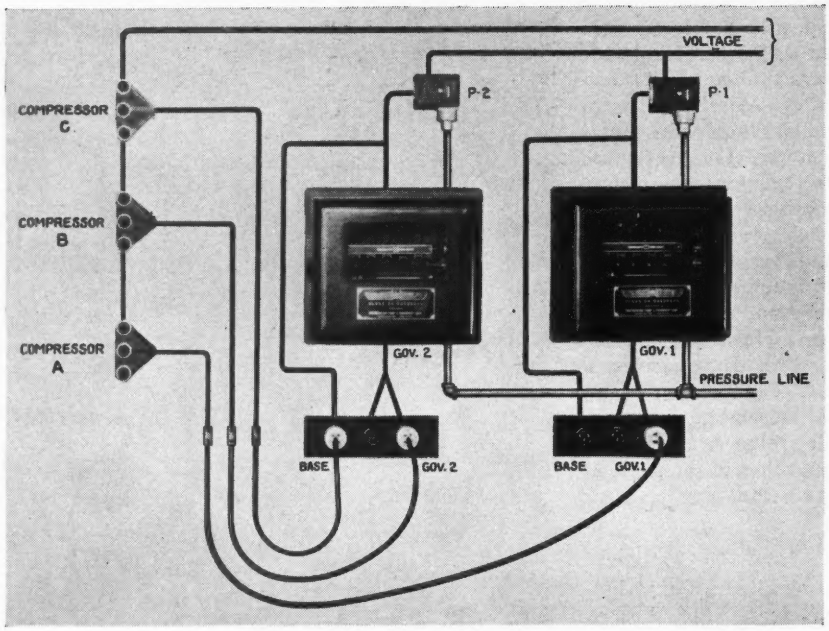


Fig. 5. Schematic arrangement showing the plugging system with two governors controlling three compressors. Compressor C is operating "base load" and compressor A as "lead off". If all three compressors are operating at full capacity and the demand drops, Gov. No. 1 first unloads Comp. A, Gov. No. 2 then unloads Comp. B and if this reduction in capacity is not sufficient, pressure switch P-2 unloads Comp. C. By changing the plugs the operating sequence of the machines can be changed. If Comp. A were plugged into the metal socket of Gov. No. 2, Comp. A and B would operate in parallel as a single large machine. By stopping the instrument in the proper position the compressor capacity can be locked at any desired capacity. In this case the loading and unloading is controlled by the pressure switch

switch and individual socket with each governor instrument and arrange the wiring so that power is also removed from the governor instrument contacts when the pressure switch opens. This makes it possible to lock any compressor, plugged to an instrument, at a given capacity by stopping the governor instrument in that capacity position. The pressure switch will then completely unload the compressor at its predetermined pressure.

When three compressors operate in parallel on the same system, usually at least one of them will be required to operate as a "base load" compressor. In other words, under normal service its full capacity is always required and it runs at 100 per cent load with variations in demand met by loading and unloading one or both of the other compressors. With a conventional compressor plant in which each compressor has its individual governor, it would be necessary to adjust each governor in order to obtain this operation, and furthermore, it would be necessary to readjust each governor whenever a different machine was to be selected for "base load" or for the "lead-off" machine.

With the multiple compressor control panel such adjustments are made only once (unless operating conditions are altered). Governor No. 1 becomes a lead-off governor with governor No. 2 set to follow at a slightly higher pressure. On a decrease in pressure governor No. 2 will load first with governor No. 1 following at a slightly lower pressure. In other words, the pressure bands of the governor instruments overlap. The pressure switches are adjusted as mentioned above and arranged to reclose at a pressure somewhat above the lower pressure limit of the governor instrument with which it is associated.

Let us suppose that our three compressors are numbered A, B and C, as in Fig. 5, and that the operating schedule requires compressor A as the lead-off compressor with compressor C used as base load. This sequence is established as follows: place the plug from the solenoids on compressor A in the socket wired to governor No. 1; place the plug from the solenoids on compressor B in the No. 2 governor socket; place the plug from the solenoids on compressor C in the socket receiving power from the No. 2 governor pressure switch. It is unimportant whether the compressors have been started before this plugging is made, since by a simple interlock with the motor starter the solenoids on each compressor may be held deenergized until the compressor motor is definitely up to speed or synchronized and ready to take its load. This interlocking is generally referred to as automatic initial unloading.

As pressure builds up in the receiver system, governor No. 1 will respond first, unloading compressor A in steps. As the pressure continues to rise, governor No. 2 will respond, unloading B in steps. At any point, should the pressure drop, the compressors will reload. It is assumed that the demand is sufficient to require the full capacity of compressor C without unloading. Should the demand change or be abruptly terminated, however, the system is fully protected, since compressors A and B will be unloaded by governors No. 1 and No. 2, then as the pressure builds up slightly above the setting of governor No. 2, its pressure switch will open, deenergizing the solenoids and completely unloading compressor C. All three compressors will now be idling on the line ready to pick up the load as required.

With a decrease in pressure, the pressure switch will close, allowing compressor C to pick up its base load. Compressor B will next pick up its load and, then if there is sufficient demand, compressor A will also be reloaded.

With the above arrangement, it is only a matter of seconds to change the sequence of compressors. Any compressor may be lead-off compressor, or any compressor may be used to carry base load. With machines of different capacities in a plant, it may be found desirable to shift base load once or twice during a normal day's service.

New 170,000 lb. per hr. integral furnace boiler incorporating a unique bark burning arrangement. New unit designed for 900 lb., 750 deg. F. anticipates a topping turbine which will reduce the steam generated 25 per cent and the steam condensed 60 per cent over present operation.

Cutting Costs with Industrial Tops

By GEORGE H. SPAULDING
Superintendent of Power
Kimberly-Clark Corp., Neenah, Wis.

BECAUSE of increased process requirements it became necessary to expand both the steam and electric generating capacity of the Kimberly (Wis.) plant of the Kimberly-Clark Corp. A study of the problem indicated that a high pressure boiler and topping turbine would supply the requirements at the lowest overall cost of power.

The old boiler equipment, with a capacity of about 265,000 lb. of steam per hr. at 200 lb. pressure, 460 deg. F. total temperature, consists of four 823 hp. boilers, three fired with pulverized coal and one with a stoker for burning a combination of coal and wood refuse. Space had been provided in the boiler room for two small boiler units for future expansion and into this space was fitted a 170,000 lb. per hr., 900 lb., 750 deg. F. integral furnace boiler equipped with two 5 ft. 6 in. Hofft refuse furnaces. The completed boiler will be fired with two pulverizers and will produce full output either with coal alone or with a combination of fuels. Only one pulverizer was installed initially, and the boiler is being operated temporarily at 200 lb. pressure.

Application of the refuse burning equipment varies from the usual method even for this type of unit. The Hofft furnace is set back from and below the level of the pulverized coal furnace as shown in the sectional view. This is done to provide a secondary combustion space for the wood refuse, which contains 55 to 60 per cent moisture, so as to burn it as completely as possible even at high rates of firing.

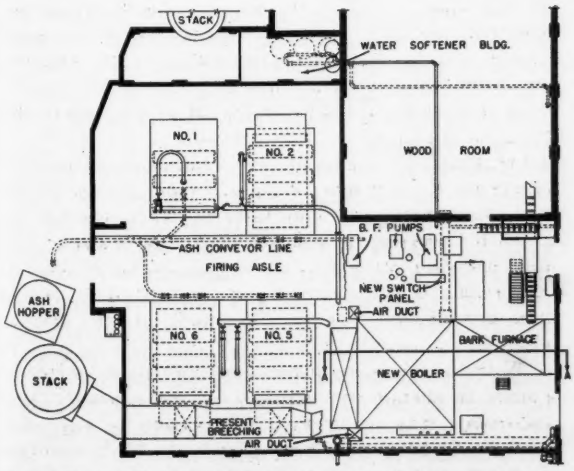


Fig. 1. The new boiler is installed in the present boiler room in space originally intended for two smaller units. The four old boilers have a total capacity of about 265,000 lb. per hr. at 200 lb., 460 deg. F. Section A-A through the new unit is shown by Fig. 3

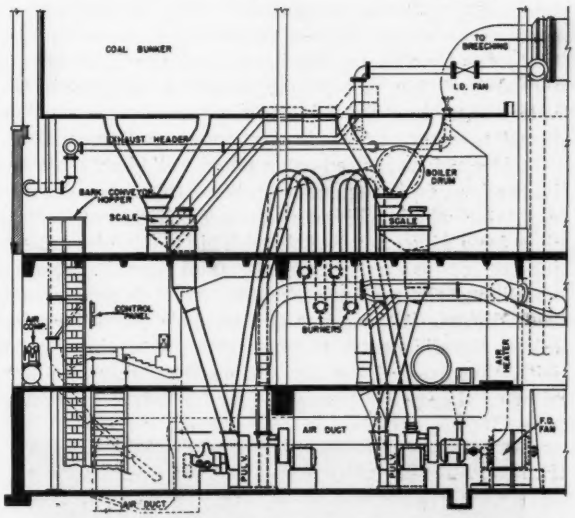


Fig. 2. Front elevation of the new boiler. Only one of the two mills shown has been installed, the one on the left will be added later. The forced draft fan is installed in the basement, the induced draft at the top of the boiler discharging to an existing stack through a breeching serving two of the old boilers

Perhaps the most interesting feature of the installation is the combustion control. As no bark storage is provided, the problem is to burn the refuse at the rate it is supplied from the barking operation, and at the same time vary the coal and air mixture to regulate steam pressure. All air for combustion is supplied by a single forced draft fan, and both furnaces have a common air heater. All air passes through the air heater except that required for tempering the coal-air where the temperature averages 200 deg. F. Leaving the air heater, ducts are run to three points: the Hofft furnace, primary air to the pulverizers and secondary air to the coal burners.

Rate of steam generation is varied by changing the rate of flow of primary air which in turn varies the rate of coal flow. The same impulse, controlled from

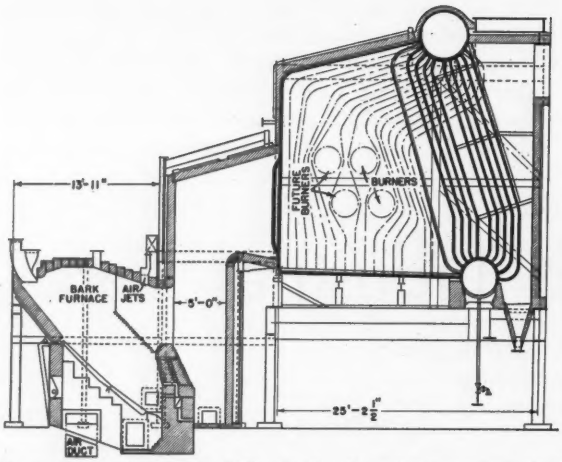


Fig. 3. Section through the boiler showing the unique arrangement of the refuse or bark burning furnace. Contrary to usual practice, this furnace is set back from, and below, the pulverized coal furnace so as to provide a secondary combustion space. The bark burned contains from 55 to 60 per cent moisture.

steam pressure, is passed through a ratio relay which sends an impulse to a regulator. This impulse is balanced against the differential pressure across the air heater and positions the louvres at the inlet of the forced draft fan. By proper design of the ports in the valve controlling the primary air damper, it is possible to get the correct coal-air mixture at the burners.

Since refuse is fired at an uncontrolled rate, air for its combustion is regulated by hand through a damper regulator which will maintain a constant rate of air flow for a given hand setting. This is done by balancing the impulse sent out by the hand regulator against the differential pressure across an orifice in the air duct. This differential pressure also controls the differential across the air heater through a regulator in parallel with that controlling air for coal burning, so that, either a change in demand for air for refuse or for coal burning repositions the louvres of the forced draft fan independently of the other.

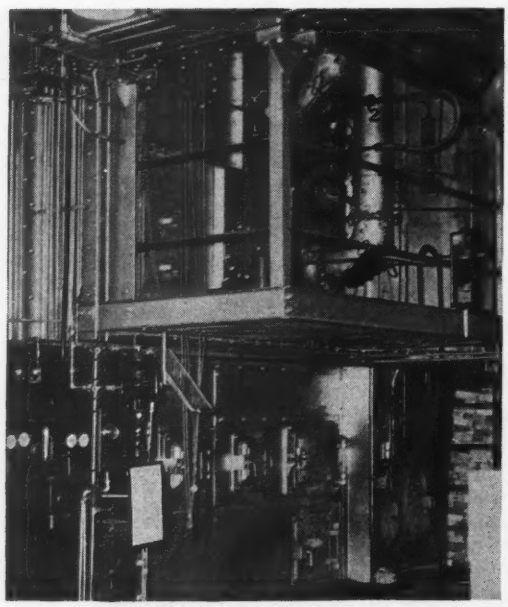


Fig. 4. View of the boiler front

The economy of the boiler installation lies in the generation of a relatively large amount of steam in a small space. By combining the two fuels a spare refuse burner is obtained at low cost and provides for economical generation of high pressure steam from a low grade fuel.

When the power demand requires additional generating equipment a 5000-kw. turbine generator will be installed as a topping unit for the present turbine generators. It will receive steam at the throttle at 850 lb., 750 deg. F. and exhaust at 200 lb., 480 deg. F. Space is available in the present turbine room for a third unit so that the topping unit can be installed and exhaust into the header supplying the lower pressure units.

LIST OF PRINCIPAL EQUIPMENT

Engineering: Kimberly-Clark Corp. Engineering Dept. C. W. Nelson, Chief Engineer.
Steam Generator: Babcock & Wilcox Co., one integral furnace type, capacity 170,000 lb. per hr., 900 lb., 750 deg. F. Boiler heating surface, 14,400 sq. ft.; air heating surface, 12,700 sq. ft.
Coal Pulverizer: Babcock & Wilcox Co., one size 135 Class 211B, with B. F. Sturtevant Co. feeder type blower and Bailey Meter Co. pulverizer feeder controller.
Bark Furnace: M. A. Hofft Co., two 5 ft. 6 in. wide furnaces.
Forced and Induced Draft Fans: Buffalo Forge Co., one each per boiler. Forced draft fan with inlet vane control and driven by a 125 hp. Gen. Elec. constant speed motor. Maximum capacity 54,000 c.f.m. at 9.0 in. water. Induced draft fan, single inlet, driven by Westinghouse 350 hp. turbine. Maximum capacity 126,000 c.f.m. at 11.75 in. water, 924 r.p.m.
Coal Scales: Richardson Scale Co., one 200 lb. capacity.
Water Column: Diamond Power Specialty Corp., one Bi-Color.
Safety Valves: Consolidated Ashcroft Hancock Co., Inc.
Feedwater Regulator: Swartwout Co., one differential pressure regulator, one feedwater level regulator.
Blow-off Valves: Babcock & Wilcox Co.
Soot Blowers: Diamond Power Specialty Corp.
Ash System: United Conveyor Corp.
Steam Flow Meter: Bailey Meter Co.
Smoke Indicator: Bailey Meter Co.
CO_2 Recorder: The Hays Corp.
Combustion Control and Panel: Hagen Corp.
Automatic Steam Valve: The Edward Valve & Mfg. Co., Inc.
Feedwater Stop and Checks: The Edward Valve & Mfg. Co., Inc.
Steam Stop Valve: The Chapman Valve Mfg. Co.

The present generating equipment includes two 3000 kw., 0.8 p.f. condensing turbines receiving steam at 200 lb. pressure and having a bleed point at 20 lb. There are also three smaller stand-by units totaling 3300 kw. which are used to replace hydro power during poor water periods.

Economy of the topping turbine can best be illustrated by the following figures: The average process steam requirement at 200 lb. is 20,000 lb. per hr. and at 20 lb., 100,000 lb. per hr., while the steam electric load is 9000 kw. To supply this steam and power demand with present boiler and generating equipment requires 205,000 lb. of steam per hr., exclusive of boiler house steam usage. With the same process requirements but with the 900 lb. boiler and topping turbine in operation, but 152,000 lb. of steam per hr. will be required and steam to the condenser will be reduced by the difference, or 53,000 lb. per hr.

Thus the installation will supply both needed power and steam requirements at a very nice saving in power costs.

Surface Condenser Performance

Simplified charts aid in making rapid calculations to determine the effect of changing conditions.

By E. F. STALCUP

Westinghouse Electric & Mfg. Co.

TO THE POWER PLANT ENGINEER or designer, it is frequently important to be able to predict the approximate performance of a surface condenser, or, to determine the surface and water requirements of a condenser for a given duty. There are many variables involved in calculating this problem, such as: inlet water temperature, size, gage and length of tubes, number of water passes, surface, water quantity, and cleanliness of the tubes. The calculations are rather laborious, unless one uses them frequently, so an effort has been made to cover the commonly used values on charts from which the results might be easily determined.

For power plant application, the most commonly used sizes of tubes are ¾, ⅞, and 1 in. outside diameter, with a wall thickness of No. 18 B.W.G. The two* following charts have been constructed, one for ¾ and the other for 1 in.* tube sizes, which may be used for obtaining the approximate performance of the present design of Westinghouse surface condensers. Headings at the top left of the chart indicate that the vertical lines correspond to inlet water temperatures from 50 deg. F. to 90 deg. F.

These vertical lines intersect lines showing condenser vacuum in inches of mercury referred to a 30-in. barometer. The upper right section shows lines indicating "Values of C." C equals gallons per minute of water divided by square feet of surface, or, water velocity in feet per second divided by the total tube length times a factor which is constant for the given size and gage of tube. This factor is 0.1885, 0.155 and 0.1215, respectively, for ¾, ⅞ and 1 in. O.D. tubes. Total tube length equals the active tube length in feet times the number of water passes. The lower right section of the chart shows lines indicating the total tube length in feet. A vertical scale to the left of these lines indicates "Steam Condensed, in pound per hour per square feet of surface."

Three examples below illustrate how these charts may be used.

It is possible, with the various values of C and total tube lengths, to get a wide range of water velocities. It should be noted, however, that the performance indicated should not be used for water velocities above 8 ft. per sec. The majority of commercial installations fall between 5½ and 7½ ft. per sec. velocity, so that, for convenience, the values of C for three velocities in this range are shown on the charts.

The charts are based on commercially clean tube performance. Many engineers and operators allow for a moderate amount of tube fouling, such as occurs between periodic tube cleanings, also for the aging action of the tubes over a period of years. While the charts cannot be used to determine an accurate result with such an allowance, they may be useful to obtain a close approximation. A common means employed to allow a margin is to specify the condenser design and performance to be used on "tubes 85 per cent clean." The practical result of this is to increase the size of the condenser and the quantity of water circulated, by approximately 10 per cent.

A margin may be allowed also, by designing the condenser on a clean tube basis, for a vacuum somewhat higher than is desired as an average over the cleaning periods. As an example, if a condenser is cleaned when the average vacuum drops 0.3 in. and it is desired to maintain an average vacuum of 28 in. with 75 deg. F. water, designing for 28.15 in. with 75 deg. F. water on a clean tube basis, would allow a margin for tube fouling and approximately obtain an average of 28 in. vacuum.

*Charts have been made for all three tube sizes but only two are reproduced here. Prints of the third chart for ⅞ in. tubes are available and, for the next month, will be sent free of charge to subscribers desiring a copy. Address Editorial Department, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

EXAMPLE 1

Make the following assumptions and then find the size of condenser and amount of circulating water required:

Steam flow from turbine to condenser, lb. per hr.	50,000
Vacuum desired referred to 30 in. barometer, in. Hg	28.5
Inlet water temperature, deg. F.	65
Water velocity through tubes, ft. per sec.	6.5
Tube size, in. O.D.	¾
Active tube length, ft.	14
No. of water passes	2
Total tube length, 2x14 ft. or	28
Then C is 6.5 ÷ (28 × 0.1885) or	1.232

From near the upper left corner of the chart, find 65 deg. F. inlet water temperature, and proceed downward on this vertical line to its intersection with the 28.5 in. vacuum line, then horizontally to the right to the point at which C = 1.232. From this point proceed downward vertically to the 28 ft. total tube length line, then to the left to the scale "Steam Condensed, lb./hr./sq. ft. surface." This point is approximately 11.40 lb. per hr. per sq. ft. Then using the formulae on the opposite page, 50,000 lb. per hr. ÷ 11.40 = 4,380 sq. ft. surface and 4,380 sq. ft. × 1.232 = 5,395 g.p.m.

EXAMPLE 2

Assume the following values and then determine the vacuum which can be obtained with various water temperatures:

Steam flow from turbine to condenser, lb. per hr.	150,000
Condenser surface, sq. ft.	12,000
Water circulated, g.p.m.	13,200
Size tubes, in. O. D.	¾
Active tube length, ft.	13
No. of water passes	2
Total tube length, 2x13 ft. or	26
Then the steam condensed in lb. per hr. per sq. ft. is (150,000 lb./hr.) ÷ (12,000 sq. ft) or	12.5
Also C is (13,200 g.p.m.) ÷ (12,000 sq. ft.) or	1.1
Water velocity in ft. per second is then 1.1 × 26 × 10.1885 or	7.46

From 12.5 lb. per hr. per sq. ft. on the lower left hand scale proceed to the right horizontally to 26 ft. total tube length, then vertically upward to C = 1.1, and left horizontally to the intersection with the desired water temperature lines, which run vertically. This shows the following results:

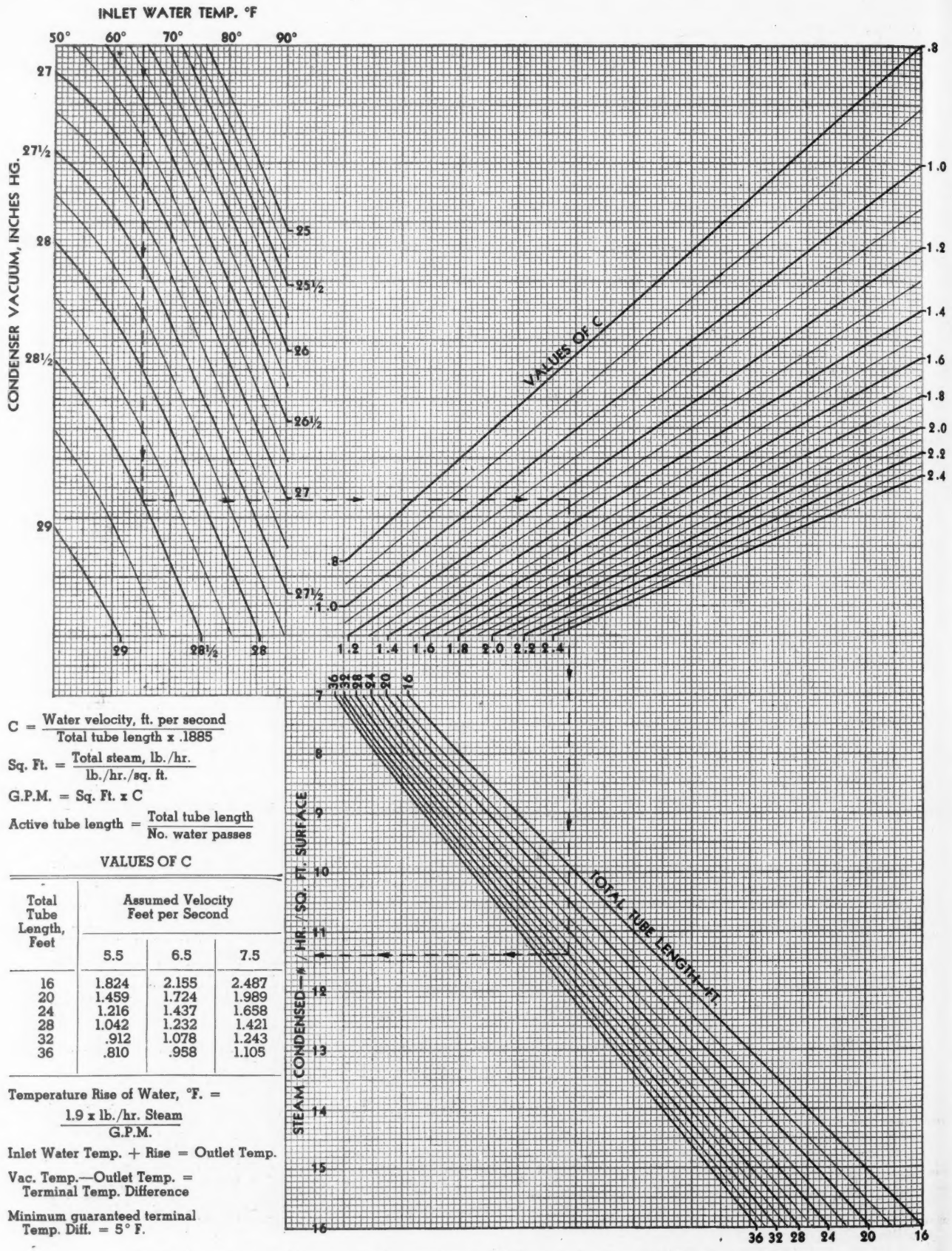
Water Temp. Deg. F.	Vacuum, In. Hg.
90	26.7
80	27.45
70	28.1
60	28.50
50	28.80

EXAMPLE 3

It is desired to find the quantity of water required with a given condenser to produce a given vacuum with a given temperature of water. To illustrate this, make the following assumptions:

Steam flow from turbine to condenser, lb. per. hr.	15,000
Condenser surface, sq. ft.	1,000
Vacuum desired, in. Hg.	27.0
Inlet water, deg. F.	80
Size tubes, in. O. D.	¾
Active tube length, ft.	10
No. of water passes	3
Total tube length is 3 × 10 ft. or	30
Then the steam condensed in lb. per hr. per sq. ft. is (15,000 lb. per hr.) ÷ (1,000 sq. ft.) or	15

First locate the intersection of 27.0 in. vacuum line and 80 deg. F. inlet water temperature line in the upper left hand corner. Then, from 15 lb. per hr. per sq. ft. on the lower left hand corner scale proceed to the right horizontally to 30 ft. total tube length line, and then vertically upward to the intersection with a horizontal line through the point first located. This shows a value of C = 1.16 approximately. Then using the formulae (1,000 sq. ft.) × 1.16 = 1,160 gal. per min. of water required, and the water velocity will be 1.16 × 30 × 0.1885 = 6.56 ft. per sec.



$$C = \frac{\text{Water velocity, ft. per second}}{\text{Total tube length} \times .1885}$$

$$\text{Sq. Ft.} = \frac{\text{Total steam, lb./hr.}}{\text{lb./hr./sq. ft.}}$$

$$\text{G.P.M.} = \text{Sq. Ft.} \times C$$

$$\text{Active tube length} = \frac{\text{Total tube length}}{\text{No. water passes}}$$

VALUES OF C

Total Tube Length, Feet	Assumed Velocity Feet per Second		
	5.5	6.5	7.5
16	1.824	2.155	2.487
20	1.459	1.724	1.989
24	1.216	1.437	1.658
28	1.042	1.232	1.421
32	.912	1.078	1.243
36	.810	.958	1.105

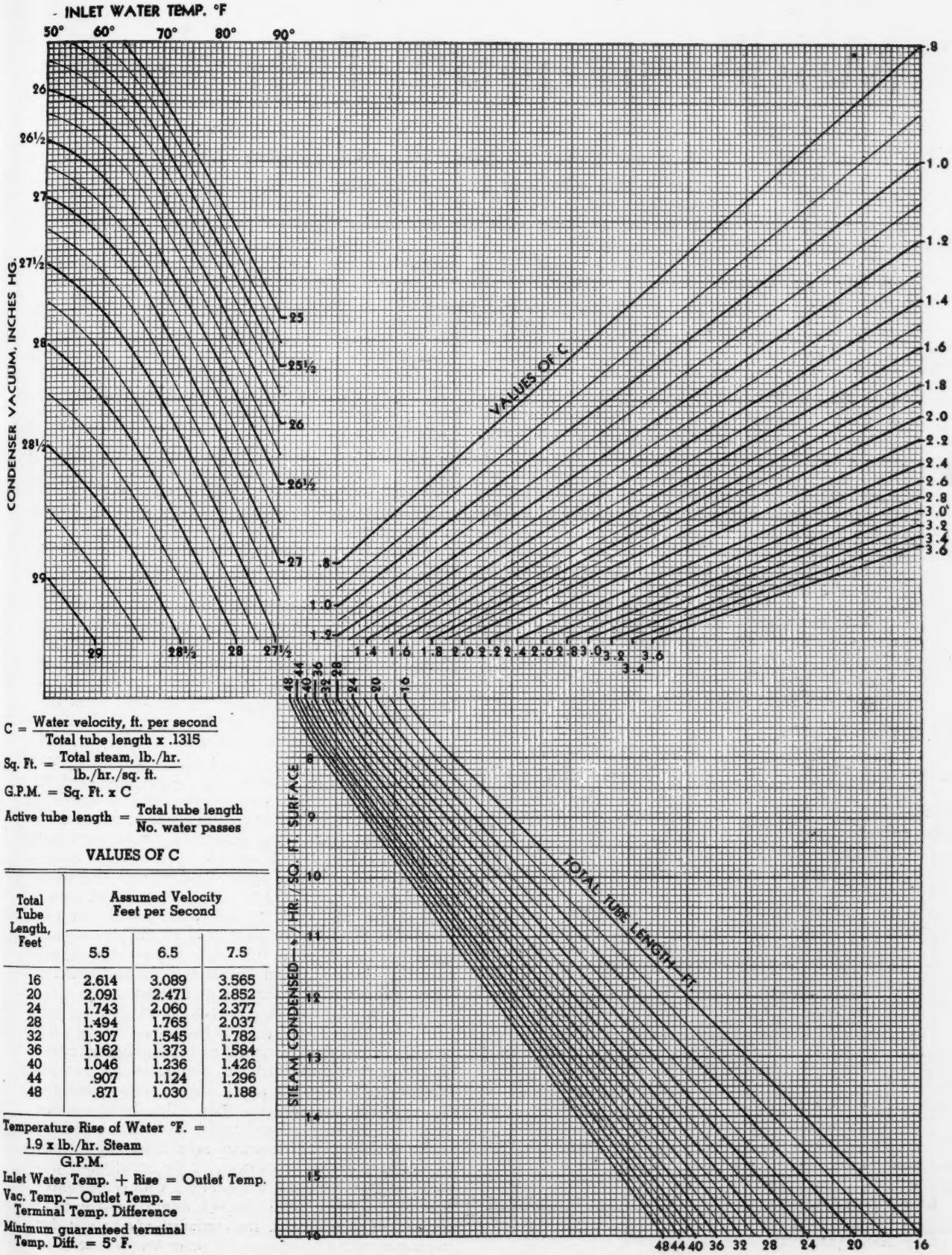
$$\text{Temperature Rise of Water, °F.} = \frac{1.9 \times \text{lb./hr. Steam}}{\text{G.P.M.}}$$

Inlet Water Temp. + Rise = Outlet Temp.

Vac. Temp.—Outlet Temp. = Terminal Temp. Difference

Minimum guaranteed terminal Temp. Diff. = 5° F.

Fig. 1. Approximate performance of surface condensers with ¾ in. O. D. tubes, 18 BWG., commercially clean



$$C = \frac{\text{Water velocity, ft. per second}}{\text{Total tube length} \times .1315}$$

$$\text{Sq. Ft.} = \frac{\text{Total steam, lb./hr.}}{\text{lb./hr./sq. ft.}}$$

G.P.M. = Sq. Ft. x C

$$\text{Active tube length} = \frac{\text{Total tube length}}{\text{No. water passes}}$$

VALUES OF C

Total Tube Length, Feet	Assumed Velocity Feet per Second		
	5.5	6.5	7.5
16	2.614	3.089	3.565
20	2.091	2.471	2.852
24	1.743	2.060	2.377
28	1.494	1.765	2.037
32	1.307	1.545	1.782
36	1.162	1.373	1.584
40	1.046	1.236	1.426
44	.907	1.124	1.296
48	.871	1.030	1.188

$$\text{Temperature Rise of Water °F.} = \frac{1.9 \times \text{lb./hr. Steam}}{\text{G.P.M.}}$$

Inlet Water Temp. + Rise = Outlet Temp.

Vac. Temp.—Outlet Temp. = Terminal Temp. Difference

Minimum guaranteed terminal Temp. Diff. = 5° F.

Fig. 2. Approximate performance of surface condensers with 1 in. O. D. tubes, 18 BWG., commercially clean

Modernization Trends In

Part II.* In this installment, the author considers textile mills which can be classified under Group II as described in the first part of this article and also a portion of those mills classified under Group III.

By M. K. BRYAN

Chas. T. Main, Inc.,
Boston, Massachusetts

IN THE FIRST PART of this discussion of the power policies in the textile industry we considered that group of mills whose service requirements were most favorable for purchased power.

Now we will consider the second group in our classification,[1] namely, that group of mills having service requirements which are probably favorable for some power generation.

Group 2—Mills with Service Requirements Probably Favorable for Some Power Generation

Mills in the second group of Table I[1] have a larger ratio of steam to power consumption, about twice that of mills in the first group. These second group mills do processing of the material which the first group do not do, and these added processes require heat. Ordinarily this process heat can be furnished in relatively low pressure steam, which condition is a potential source of cheap power. Although this source of power is generally not large enough in proportion to total mill power requirements to generalize that purchased electricity can not be competitive, it is always of enough magnitude for private power generation to be seriously considered, and especially wherever the ultimate of profitable mill operation is dependent upon operating expense. For example, a colored goods cotton mill will accept or refuse cloth orders on a price margin of 0.1 to 0.25 cent per yd. A typical colored goods mill for the past four years has averaged to use 0.32 kw-hr. per yard of cloth. So, accordingly, a variation in power cost of 3 to 8 mills a kilowatt-hour may be the difference between meeting the market at a profit or at a loss.

*Part I appeared on page 104 of the February 1938 issue.
[1]See Table I in Part I. Page 106 February, 1938.

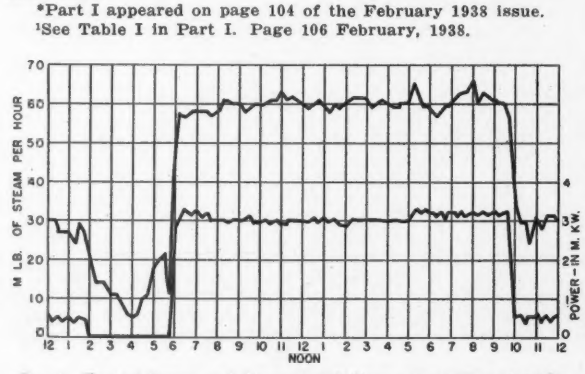


Fig. 2. Typical Power and Steam Load Curves for Group 2 Mills

A cotton mill typical of those in Group 2, excepting that it is larger than the average, may be used to illustrate the results, generating all power and steam. This mill operates on a two-shift or 80 hr. per week basis, making colored cotton goods. Some process work is on a 24 hr. basis. It has been making all power since 1934, prior to which some power was made and some purchased.

Typical daily power and steam load curves are shown in Fig. 2. Annual load factors for the past four years have ranged from 37.5 to 51.2 per cent and averaged 46 per cent for the period. Space heating steam, for which there is little demand, and steam for process purposes, are supplied 80 per cent from the steam turbine and 20 per cent direct from the boilers. The turbine is bled at two points to deliver 90 lb. and 20 lb. steam, about 21 per cent of the throttle steam being bled at 20 lb. pressure and 14 per cent of it at 90 lb. pressure. The process and heating load amounts to about 7 lb. of steam for each kilowatt of power used in the mill. Total steam generated for all purposes amounts to about 19.1 lb. per kw. of power used in the mill. Records for this plant show average operating costs for four years of 4.16 mills per kw-hr. of power used in the mill, equal to 1.33 mills power cost per yard of cloth. Cost per yard of cloth for process and space heating steam is 0.57 mills. These figures are operating costs only and do not include anything for taxes, insurance, depreciation, or interest.

The equipment in the plant from which these figures were taken, consists of 3 stoker-fired water-tube boilers and one double extraction condensing type turbine-generator unit. Steam conditions at turbine throttle are 250 lb. per sq. in. gage pressure and 575 deg. F. total temperature. Extraction pressures are 90 lb. and 20 lb. gage, and terminal condition is 2 in. mercury absolute. The boiler plant does not include economizers or air preheaters. This installation was made largely in an existing building with some simple alterations, for a total cost of approximately $110 per kw. of demand. A fair estimate of the cost for steam generating equipment for process work, exclusive of any power generating requirements, is equivalent

Textile Mill Power Plants

to $20 per kw. of power demand, leaving $90 per kw. of demand chargeable against power.

These figures can be expressed in other language as follows:—the cost of power is about $1.00 per mo. per kw. of demand plus 4¼ mills per kw. of energy charge.

The management in this case did not go as far in the development to lower power cost as some might think desirable. An increase in steam pressure to 400 lb. at the throttle and the addition of air preheaters would have affected only the boiler plant installation costs and would have saved, roughly, 12 to 13 per cent more coal, equivalent to about 20 per cent per year on the added investment.

The woolen plants in this classification are, in general, handicapped as compared to the cotton mills, by their relatively small size and consequently small power and steam loads, making high unit cost for the power plant equipment.

Plants in this middle classification, both cotton and wool, are likely to find steam power preferable to Diesel power generation, for the reason that process steam needs will require an appreciable steam generating plant, a condition which is a financial hardship to a Diesel installation.

Group 3—Mills with Service Requirements Most Favorable for Steam Power Generation and for High Economy Steam Generation

These are the plants of the third group of Table 1. This group includes the largest plants in the wool division of the industry as well as many smaller plants. It is exceptional when a mill in this group does not make some power. Most of them make all power required, and there are a few mills making no power from steam and buying the requirements which can not be supplied by existing water power developments.

Mills in this grouping need large quantities of heat for the processes, and this can generally be supplied from relatively low pressure steam. Most of these plants have a 24 hr. load. The first two shifts generally have the heaviest loads of steam and power, the third shift loads being noticeably lighter with the power load reduced in a larger proportion than the steam load.

In Groups 1 and 2, previously discussed, the power plant problem is essentially concerned with the means of getting a kilowatt for the lowest practical cost. Steam generating costs are of less importance. However, for mills in Group 3, the power plant problem starts with steam generation costs and power production becomes a by-product of steam supply.

Steam for process purposes is not required at pressures exceeding 100 lb. and most of the work can be done with 5 to 10 lb. pressure steam. Although these mills are widely different in their practices of processing, process steam consumption is high per kilowatt

TABLE II

Mill	Process Steam—Pounds per Kw-hr. of Power Consumption				
	Annual Average	Summer Max.	Summer Min.	Winter Max.	Winter Min.
Cotton Finishing	115	150	105	170	130
Cotton Finishing	90	90	40	135	60
Cotton Finishing	104	103	69	132	86
Complete Worsted	19	17	7½	44	17
Wool Scouring	45				
Complete Woolen	35	55	5	65	10

of power consumption, and in many cases enough non-condensing steam power can be made from process steam to supply the load demands.

Table II gives some data which shows the general relations of cotton and woolen mills in Group 3.

The pounds of process steam used per kw-hr. varies considerably in different mills and throughout the day and year in a particular mill. Cotton fabrics require more process steam in proportion to power than woolen goods. Differences between mills are due principally to the class of goods made, and somewhat to the individual ideas of processing. Rates of production vary the ratio in the same mill and weather conditions also vary it, the winter steam requirements averaging about 30 to 50 per cent higher than the summer uses.

These variations with production and for summer and winter conditions can be illustrated by the curves, Fig. 3.

These graphs show average steam consumption per yard of cloth for each of two mills plotted against production rate for summer and for winter. The mill represented by the solid line processes goods which are about 50 per cent heavier than the goods processed in the mill represented by the dotted lines. Variations of the steam to power ratio from hour to hour for three days of mill operation are illustrated by the graph of Fig. 4.

Rough figures for average mills may be stated to be about 90 to 115 lb. of steam for cotton finishing plants with a seasonal and hourly range within the

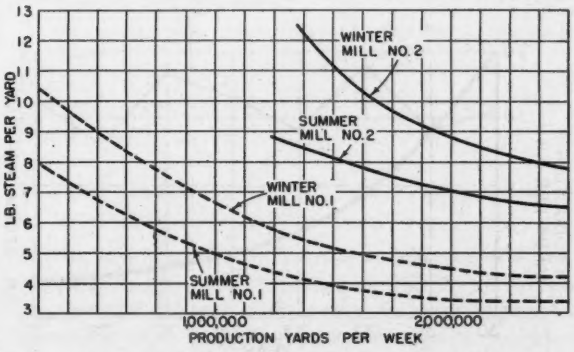


Fig. 3. Summer and winter steam used per yard of cloth vs. production

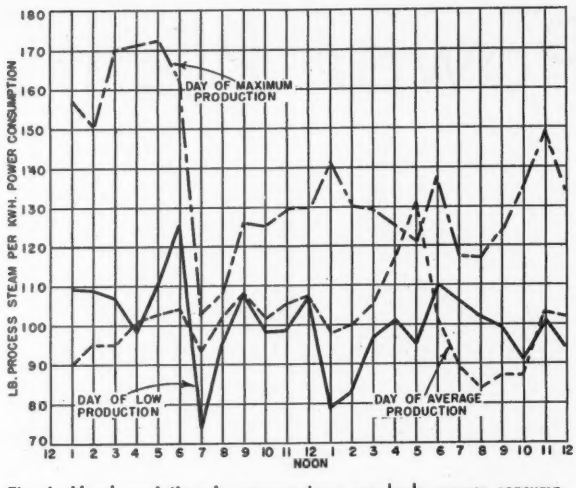

LB. PROCESS STEAM PER KWH. POWER CONSUMPTION
DAY OF MAXIMUM PRODUCTION
DAY OF LOW PRODUCTION
DAY OF AVERAGE PRODUCTION
NOON

Fig. 4. Hourly variations in process steam per kw-hr. power consumption for days of Maximum, Average, and Minimum mill production. (Cotton finishing plant)

limits of 40 to 160; for woolen mills an average of about 35 lb. with a range of 10 to 55 lb.; for worsted mills, 18 to 25 lb. average with seasonal hourly ranges within 8 to 50 lb.; for wool scouring plants 40 to 50 lb. average, with seasonal hourly ranges within 30 to 80 lb. These figures are very general.

The order of this magnitude explains the relatively low steam pressures at which most turbine plants operate, particularly in the cotton textiles. High steam pressures and temperatures have not been necessary in the past. There is a tendency toward higher steam pressures, which are definitely worth while. Mill machinery is requiring in some cases higher steam pressure than formerly for process purposes and the power consumption per unit of production is increasing at a noticeable rate, whereas heat consumption for processing is not. These changes in one mill are shown by Graph 5.

In this classification, the cost of supplying steam is greater than the cost of supplying power and steam generating costs are an important factor in manufacturing cost, in many cases amounting to more than what the market allows the mill as margin in price of the goods.

The importance of economy in steam generation is being recognized and advantage is being taken of advances in firing and steam generating equipment. This may be illustrated by an installation now being made in a southern cotton finishing plant. This plant has a steam load as shown in Fig. 6.

The power and steam plant was built with new equipment in 1928. As part of the same property, some 500 yd. away there is a plain goods cotton mill. The finishing plant and the plain goods mill are served by a central boiler plant. Power is supplied to the two mills from the utility lines and from a non-condensing turbo-generator at the finishing plant.

The boilers installed in 1928 were 300 lb. straight tube, forged steel header units, three in number, and were stoker fired. No economizers or air preheaters were installed. Steam at turbine throttle is 240 lb. pressure, 550 deg. F. total temperature. Turbine exhaust pressure is 15 lb. per sq. in. Early in 1938 the steam demands had grown enough so that the original installation was inadequate for dependable and ample steam supply. Examination of the practical possibilities to increase the plant's steam generating capacity and the relation of investments and operating costs resulted in selecting one high efficiency pulverized coal and oil fired unit to serve as a base load operating unit, the existing units to be maintained as spares and for exceptional peak demands.

The new unit, designed for the same working pressure and superheat as the old units, will have a continuous steam output capacity of 75,000 lb. per hr. with short-time peaks of 85,000 lb. per hr. This boiler is an integral furnace installation fired with one pulverizer and two circular forced draft burners, and equipped with regenerative type air preheater and motor driven forced and induced draft duplex fan with inlet vane control for each wheel. Complete combustion control system and coal handling and weighing equipment is installed. The steam generating unit is to be erected in the existing boiler house after simple building changes.

This unit will be required to develop steam through a load range of about 12 to 1. In the interest of handling the low loads certainly and safely, it was thought advisable to equip for burning No. 6 oil below about 12,000 lb. per hr. load. The oil-burning equipment will have capacity to develop 50,000 lb. per hr. and accordingly can be considered as a partial reserve against pulverizer outage.

The efficiency of this unit burning coal and producing 75,000 lb. per hr., is 86 per cent plus. The complete installation will cost about $1.45 per lb. of steam. The savings which are from labor, from improved combustion and heat absorbing efficiency, and from ability to take better advantage of the offerings of the coal market will return the investment in four years or less.

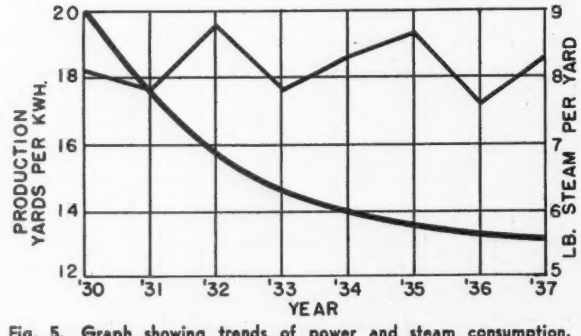


Fig. 5. Graph showing trends of power and steam consumption. Cotton finishing plant

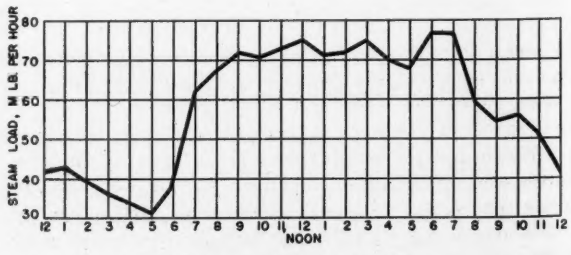


Fig. 6. Typical 24 hour steam load

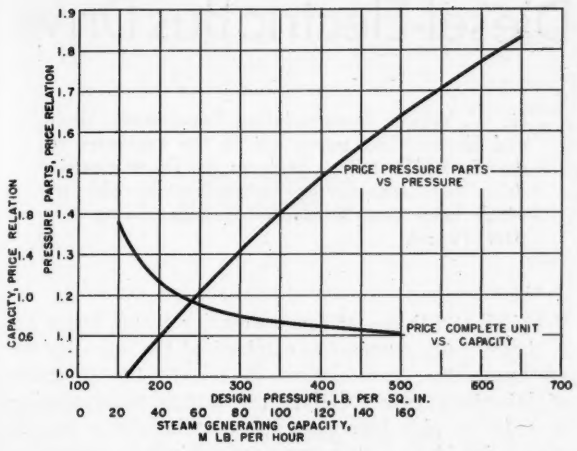

CAPACITY, PRICE RELATION
PRESSURE PARTS, PRICE RELATION
PRICE PRESSURE PARTS VS PRESSURE
PRICE COMPLETE UNIT VS. CAPACITY
DESIGN PRESSURE, LB. PER SQ. IN.
STEAM GENERATING CAPACITY, M LB. PER HOUR

Fig. 7. Price Relations—Steam Generators. Complete steam generating unit costs increase on account of pressure above 225 lb. at Boiler drums

350 lb. at drums	about 8%
450 lb. at drums	about 16%
650 lb. at drums	about 38%

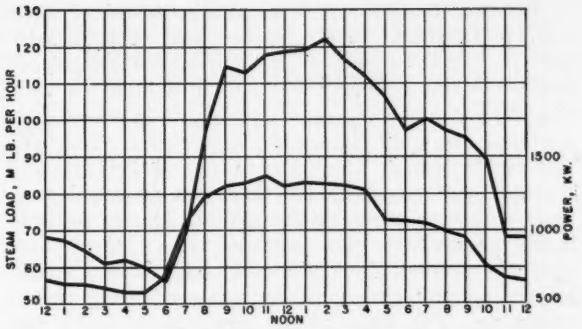


Fig. 8. Typical 24-hr. steam and power loads

It is expected that this unit will produce about 95 per cent of the annual steam requirements.

In choosing this unit, the question of steam pressure was not a factor to be considered since the power situation can be materially improved whenever the management wishes to install additional generating capacity and pass more steam through turbines and less through the reducing valves. Not much more than half of the finishing plant steam is passed through the turbines at present.

An installation similar in many respects was made in a northern Maine finishing plant last year. This installation was made for the same reasons, namely, additional steam generating capacity and improved coal burning efficiency. This installation supplemented three stoker-fired, straight tube, box header boilers installed about 1918. The new unit is a Riley Type RP unit, fired with one Atritor and two burners. The unit was designed for 450 lb. steam working pressure, 650 deg. total temperature, and is operated at 125 lb. pressure, 400 deg. total temperature. No economizer or air preheater was installed. The overall efficiency at load of 72,000 lb. per hr., continuous generating capacity rating is 80 per cent. The cost of boiler, pulverizer and burners, fans, flues and masonry setting, was about $0.62 per lb. of continuous output. This unit generates 70 per cent plus of the annual steam requirements and produces annual savings in labor and fuel cost equal to 20 per cent of the total installation cost. Fuel costs about $6.60 per ton in the boiler plant.

This mill is furnished with power from water wheels supplemented by a small amount from the utility.

These two installations were made by two financially successful manufacturers. Other similar installations have been made in the interests of fuel economy using the recently developed boiler designs. In general, these have been designed for lower steam pressures and made without economizers or air heaters. The additional cost to provide for higher pressures in the construction of steam generating units is not an amount so great that the future advantage of higher pressure can be disregarded. The relative costs of pressure parts of steam generating units as affected by design pressure is shown in Fig. 7, which also shows the relation of capacity and price of complete steam generating units exclusive of building, piping and auxiliaries.

The advisability of economizers or air heaters is roughly and generally whether an increment of investment which will reduce fuel costs enough to save its total in two to five years is desirable.

Illustration of the possibilities of combining modern equipment with existing and working toward the eventual abandonment of old equipment, is the case of a cotton plant in Group 3.

This plant has a steam and power load as per Fig. 8. Power is required both as alternating and direct current and is supplied by engine generator sets, hydro-electric plant, and local utility. Motor generator sets float between the A.C. and D.C. buses. The engines exhaust at 10 lb. into the low pressure process and building heating lines. Steam is generated at 135 pounds pressure, in oil-fired, four-drum, curved-tube boilers, and is used about as follows:

Week-end uses	5%
Engine Exhaust wasted to atmosphere	8%
Engine Exhaust used in process	30%
High pressure steam distributed at boiler pressure, for process, space heating, etc	57%
Total Steam Generated	100%

Power supply from different sources is about as follows:

Engines (A.C. and D.C.)	76%
Hydro and Electric, A.C.	15%
Utility, A.C.	9%
Total	100%

The smallest ratio of process steam to power consumption permitted a pressure of 300 lb. at turbine throttle to be chosen with leeway to allow reasonable assurance that some steam would always be taken through the reducing valve despite the trend of the ratio to decrease.

The principal sources of savings in this plant were —steam exhausted to atmosphere, cost of purchased electricity, cost of hydro-station operation and maintenance,—(this property was old, in a high tax rate district, and had small capacity)—labor in attendance upon engines, and fuel saved by better boiler efficiency. Existing boilers and engines were old and their remaining usful life was short, but there was no question of their ability to carry on for several years. Accordingly, the advisable plan appeared to be superposition upon the present plant of a new high economy steam generating unit and a bleeder non-condensing turbo-generator. This afforded the maximum of hours use for the new equipment. The steam generating unit could operate 24 hours per day at good load points and the turbo-generator could be correspondingly loaded. Load changes day and night are handled with the old boilers and the engine generator sets. No old steam equipment is removed and, accordingly, plant operation can continue uncurtailed with the new equipment stopped for maintenance or inspection.

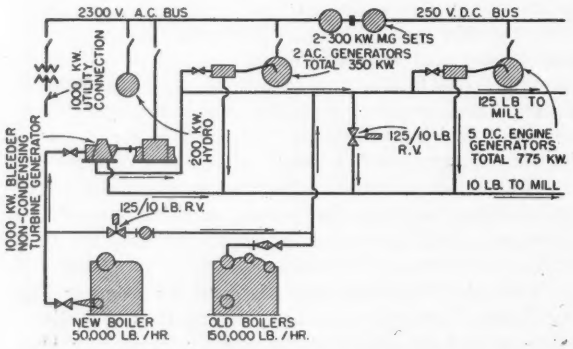

2300 V. A.C. BUS
250 V. D.C. BUS
2-300 KW. M.G. SETS
2 A.C. GENERATORS TOTAL 350 KW.
1000 KW. UTILITY CONNECTION
200 KW. HYDRO
125 LB. TO MILL
5 D.C. ENGINE GENERATORS TOTAL 775 KW.
125/10 LB. R.V.
10 LB. TO MILL
1000 KW. BLEEDER NON-CONDENSING TURBINE GENERATOR
125/10 LB. R.V.
NEW BOILER 50,000 LB. /HR.
OLD BOILERS 50,000 LB. /HR.

Fig. 9. Arrangement of equipment superposed on present plant

The new equipment was superposed upon the present as shown in Fig. 9.

This equipment was a 50,000 lb. per hour oil-fired boiler with air preheater, forced and induced draft fans, new deaerating feed heater, feed pumps, and 1000 kw. steam turbo-generator taking steam at 300 lb., 600 deg. F. total temperature, bled at 125 lb. for engine and process supply and exhausting at 10 lb. for process. This installation is to be followed by additional boilers and turbines as and when physical condition of old equipment determines their need.

Steam generated by the new unit is about 45 per cent of annual steam used in the mill, representing 5200 hr. of capacity operation per year for the new boiler.

Boiler installation including its building expenses, cost about $1.70 per lb. of steam capacity and turbine installation cost about $72 per kw. The annual savings amount to $40,000 which is about one-half of what the cloth market allows as margin in selling price on a year's output of goods at this mill.

NOTE: This is the second, of three articles on Power Practices in the Textile Industry by Mr. Bryan. The third, devoted to a consideration of woolen mills under the third grouping, will appear in the April issue.

Diesel-Electric Bus Drive

G. W. Wilson, Transportation Department, General Electric Co., points out to the engineers of the S. A. E. salient features of Diesel-electric drive for large buses, approximately 250 of which have been placed in service during the past 18 mo.

INCREASED use of large capacity motor buses for heavy duty service has emphasized the necessity for an automatic transmission to relieve the operator of laborious gear shifting and clutch manipulating in order to give him more time for handling passengers. An ideal motor bus power plant combination would consist of a Diesel engine with a fully automatic, infinitely variable ratio transmission to permit complete mechanical isolation of the power unit from the passenger compartment. Electric drive has all of these desirable characteristics and for many years has been used on motor buses with gasoline engines.

The greatest activity along this line has come during the past 12 yr. and during that time approximately 3000 electric drive buses have been placed in service in this country. Approximately 250 of these were placed in service during the past 18 mo. and were used with automatic Diesel engines. The experience gained through the operation of these electric drives has resulted in further refinements in design which are constantly improving the equipment. While even our latest electric drive is somewhat more expensive and heavier than the friction clutch and crash gear box, it is nevertheless 35 per cent lighter, 25 per cent less expensive and 3 to 8 per cent more efficient than its predecessor. In our opinion, this brings electric drive well within the competitive range of other fully automatic transmissions.

The 125 hp. traction generator is essentially a self-excited shunt wound direct current machine with a small amount of compounding to minimize the slipping clutch sensation of the older type gas-electric drives, when pulling away from a stop under full throttle. This latest design of generator complete with coupling weighs 765 lb.

The traction motor and main reverser used with the 125 hp. generator has a 6⅛ axle ratio and 42 in. tires on vehicles up to 20,000 lb. weight, not including passengers, and with seating capacities up to 40. This is a direct current series motor. It weighs 930 lb. complete and, when properly supported, cannot be heard at any vehicle speed.

One of the shortcomings of the most fully automatic transmissions is their free-wheeling action when the engine throttle is closed. We feel sure that we can successfully overcome this handicap on our electric drive by a recently completed development in electric braking. This will not only make the vehicle safer to operate in slippery weather but will substantially relieve the duty on the friction brakes.

A steam turbine would be of little use in modern interconnected power systems if no means were available to hold the speed constant under varying conditions of load and steam pressure. For this reason the governing devices with which all turbines are equipped are highly important and necessary gadgets, and they have been developed to a very high degree of perfection. For a discussion of this aspect of turbine operation we now turn the stage over to Mr. Wales of the Turbine Engineering Dept. of the General Electric Co. at Lynn who specializes in this branch of the art.

MODERN TURBINES*

By
L. B. WALES
Turbine Engineering Dept.
General Electric Co., Lynn, Mass.

SUCCESSFUL APPLICATION of industrial turbines and full realization of their maximum economy is dependent to a great extent upon the fact that they may be governed or controlled with great accuracy in terms of almost any variable desired. One manufacturer, for example, may have a process requiring constant electrical frequency. Speed governors are available which will hold the turbine generator speed constant, within 0.1 per cent or less, over his entire range of load or steam pressure variations. Another may wish to have his turbine deliver steam at a practically constant pressure to a process line and send this steam into the line only when it is needed. Another may have some intermittent supply of steam available and wish the turbine to utilize automatically what otherwise might be wasted. Still another will want his machine to supply steam to a process line at all times except when his boiler pressure is low. These widely varying requirements are met by the proper application of different types of turbines. To show how these units are controlled and to define the few simple fundamentals involved is the purpose of this and a second article.

Automatic control is accomplished by governors or regulators. A turbine is ordinarily equipped with two classes of governors which function separately and independently. One is the "operating" governor which controls normal operation, and the other is a "safety" or "emergency" governor which functions only when conditions become outside the control of the operating governor for any reason. Emergency governors generally operate a "trip" or quick acting mechanism.

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A third class known as a "pre-emergency" governor arises when a turbine is equipped with two "operating governors". For example, a turbine may have both a speed governor and an exhaust pressure regulator and may be arranged to operate under the control of either. If the unit is operated under the control of the exhaust pressure regulator, the speed governor may be set to prevent the speed from rising above a predetermined value; a value below that for which the "emergency" governor is set to act. Such a setting is called a "pre-emergency" setting.

Operating governors make use of a small variation in the quantity being controlled (speed, pressure, etc.), to bring about changes in the factors affecting the controlled quantity in such a way as to hold it within the above small variation. This small variation in the controlled quantity is known as the *regulation.*

As an example of an operating governor, consider the basic centrifugal flyball speed governor controlling an isolated turbine with the flyball position directly operating the steam admission valve; (See Fig. 1), as the balls travel in with a speed *decrease* they open the valve, or as they go out with a speed *increase* they close the valve. The flyball position is a direct indication or measure of speed. When the flyballs are out the speed is high and when they are in the speed is low. Consequently when the valve is nearly closed, as at no load, the speed is high, and as load is applied the speed will drop and the valve will open according to the characteristics of the flyballs. In order to hold the valve open, *the speed must remain at this lower value as long as the load is applied.* (Unless the speed setting is raised by hand adjustment.) This change in speed

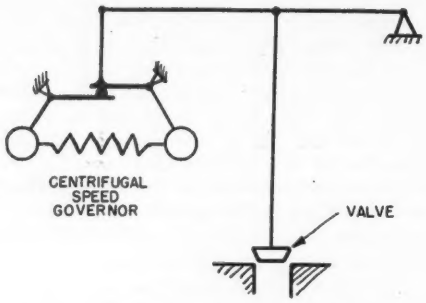


Fig. 1. Elementary Diagram of Speed Governor

with the application of load is the governor's "regulation" and is usually expressed as the per cent speed change for a load change equal to full load. This value may normally be of the general magnitude of 3 or 4 per cent of the normal speed. Thus, a turbine with a 4 per cent speed regulation, when set for 3600 r.p.m. at full load, would operate at 3744 r.p.m. at no load.

Likewise the fundamental operating pressure governor makes use of a change in the controlled pressure, acting on a diaphragm or bellows, to vary the steam supply affecting the controlled pressure. The "regulation" or pressure change required to vary the steam supply from zero to maximum may be of the general magnitude of 10 per cent of the absolute pressure being controlled.

A governor with a small percentage regulation is spoken of as a "narrow" governor and one with a large regulation is known as a "broad" governor.

Generally speaking, "broadening" a governor or increasing its regulation improves its "stability" or in other words eliminates any tendency to "hunt" which may be found if the governor is too "narrow". Thus, from the point of view of stability we would like a broad governor while for obtaining only a small variation in the controlled quantity a narrow governor would be desired. How these two opposed principles can be reconciled by the application of regulation "correctors" will be described later. For the present it is only necessary to understand that by the use of regulation "correctors" in conjunction with a broad and stable governor any desired or necessary degree of "ultimate" or "settled" regulation down to and including zero regulation may be obtained with stability and smoothness. Governors with zero regulation are sometimes termed "isochronous". The action of a governor which maintains zero regulation by means of a "corrector", is in no sense comparable with the usual conception of an isochronous governor. Strictly speaking an isochronous governor would be inherently unstable, but the term "isochronous" is commonly applied today to stable governors having relatively broad regulations for instantaneous changes, but substantially zero regulation for a settled change.

For accurate control, governors acting directly to move the steam admission valve (See Fig. 1) must be limited to small operating forces which normally prohibits their use on any but small turbines. Direct acting governors must supply the force to move the steam control valve, a requirement which limits their sensitivity and accuracy.

But sensitivity and accuracy may be retained even though large forces must be controlled by "relaying" the action of the governor. The governor itself then operates only a small pilot valve controlling fluid pressure, or other amplifying means, which secures the large forces needed for positive positioning of the control valves. With such an arrangement the governor serves simply as an indicator of the quantity being controlled and supplies little or no operating force.

The importance of this consideration may be realized by considering the variation in force encountered in lifting a 4-in. valve against an unbalanced pressure of 200 lb. per sq. in. A force of about 2400 lb. is required to start the valve off its seat. As flow through the valve increases the nozzle following the valve builds up pressure between the nozzle and the valve, so that when the valve has been lifted about ¼ in. little unbalance exists—a variation of one ton or more in ¼ in. travel!

Various "relay" systems have been developed for fast and accurate control of large forces. The most accurate and positive of these always make use of "restoring" in one form or another. In other words after a force has been set up tending to accomplish a result, the accomplishment of that result automatically removes the force.

Figures 2 and 3 illustrate "position" and "force" restoring respectively. In each case "a" represents the pressure sensitive element of a pressure regulator, "b" the pilot valve controlling the flow of high pressure oil to "c", an operating piston capable of positioning suitable valves controlling steam flow to the system under the control of "a".

The use of relays, while giving a practically unlimited extent to what may be controlled by governors does not, however, alter the fundamental concepts gained from Fig. 1 whether it be applied to speed governors, pressure governors or what not.

It frequently becomes necessary to operate two or more governors in parallel, i.e., have two or more gov-

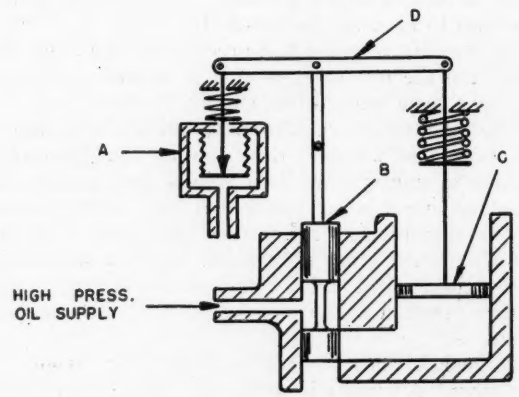


Fig. 2. Position Restoring

An increase in pressure at (a) causes the pressure responsive element to move upward a definite amount depending upon the characteristics of its spring. In moving upward the pilot valve is displaced from its neutral position in the direction to drain oil from the underside of piston (c). The piston (c) will move downward under the influence of its loading spring until the pilot valve has been restored—through restoring lever (d)—to its neutral position.

A decrease in pressure at (a) will cause the pilot valve to move downward and admit oil under pressure to the piston (c). The piston (c) will move upward until the pilot valve is restored to its neutral position.

ernors in active control of the same quantity at the same time.

For example, consider two or more speed governed turbine-generators synchronized on the same bus. During such operation the speed of all units must be the same since their generators are electrically locked together. With the application of load to such a system, the system frequency, or speed, decreases until the total increase in output on all the units (caused by the drop in speed moving their governors and hence their steam admission valves) is just equal to the applied load. Since the per cent speed drop is the same on all units, those with "narrow" regulations will have their outputs increased relatively more than those with "broad" regulations. Since by definition "regulation" is the per cent speed change for a full load change, the actual load increase on any unit will be in proportion to the full load rating of that unit in relation to the total of the full load ratings of all units on the system. Generalizing these statements we may say that *the division of load between units will be inversely as their regulations and directly as their ratings.*

To illustrate, suppose we have a 1000 kw. unit with 2 per cent regulation operated in parallel with a 4000 kw. unit of 4 per cent regulation. How will a system load change of 3000 kw. be divided between them? We will first see what the system speed change "S" will be.

System load change = load change on the 1000 kw. unit + load change on the 4000 kw. unit.

$$3000 = \frac{S}{2} \times 1000 + \frac{S}{4} \times 4000$$

$$3000 = S \times 500 + S \times 1000$$

$$3000 = 1500 \times S$$

$S = 2$ per cent system speed change.

A two per cent speed change on the 1000 kw. unit which has 2 per cent regulation for a full load change will change the load on it by 1000 kw.

A two per cent speed change on the 4000 kw. unit which has 4 per cent regulation for a full load change will change the load on it by 2000 kw.

If the governor on one of the units were equipped with a regulation "corrector" arranged for zero settled regulation, it would, of course, absorb any settled system load change within its capacity, and maintain constant system speed. The governors on any other units on the system would have no settled speed change to respond to and those other units would operate at constant load or "base-loaded".

These principles may be applied to almost any system involving two or more governors of nearly any type operating in parallel, whether controlling speed, pressure, or other variables.

Particular use of these principles may be found in arranging the control of various units in a station so that most economical operation is as nearly automatic as possible and requires a minimum of the operator's attention.

For instance, for most economical operation, units should be started up, to meet increasing plant loads,

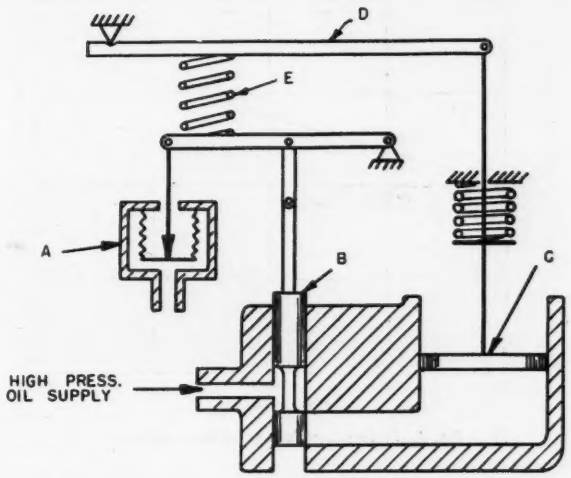


Fig. 3. Force Restoring

An increase in pressure at (a) causes the pressure responsive element to move upward compressing spring (e), and displacing pilot valve (b) in the direction to drain oil from beneath piston (c). Piston (c) moves downward under the influence of its loading spring until, through its restoring lever (d), it compresses spring (e) enough to overcome the increased pressure at (a) and restore the pilot valve (b) to its neutral position.

A decrease in pressure at (a) causes a similar action except that the piston (c) is moved upward by oil under pressure.

other things being equal, in the ascending order of their "actual steam rates", i.e., their actual steam flow divided by their kw. output. When it is necessary to have more than one unit on the line, they should be loaded in the ascending order of their incremental steam rates, i.e., the change in actual steam flow between no load and full load divided by the full load kw. output.

Consider, for example, two 1000 kw. units, the performances of which are represented by No. 1 and No. 2 respectively in Fig. 4. These figures, while exaggerated, will serve the better to illustrate the truth of the two above generalizations.

Obviously, for plant loads of less than 1000 kw. it is advantageous to operate No. 1 rather than No. 2. When, however, the load becomes in excess of 1000, say 1250 or 1500 kw. and it is necessary to operate both units, the least total steam plan will result with No. 2 at full load and the balance on No. 1 although No. 2 has an "actual" full load steam rate of 35 lb. per kw-hr. while that of No. 1 is only 30 lb. per kw-hr. With both units operating the factor determining most economical loading is "incremental steam rate" which for No. 2 is 15.0 lb. per kw-hr. and for No. 1 is 20.0 lb. per kw-hr. This applies for all loads for which both units must be operated.

Station K.W.	Unit No.	Unit Load	Throttle Flow	Unit Load	Throttle Flow
1250	1	250	15,000	1000	30,000
	2	1000	35,000	250	23,750
		1250	50,000	1250	53,750
1500	1	500	20,000	1000	30,000
	2	1000	35,000	500	27,500
		1500	55,000	1500	57,500

Obviously then, when the station load is such that both units should be operated, No. 2 should be operated at as near full load as possible and the balance placed

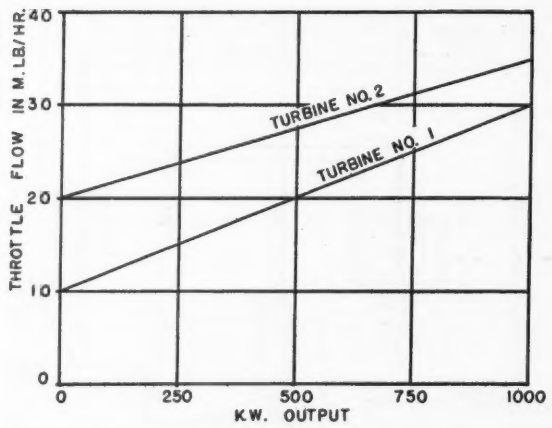


Fig. 4. Performance curves of two turbines

on No. 1 and No. 1 should take any changes in station load that may occur, within its capacity. One way to accomplish this is to make No. 1's regulation very narrow. If the regulation of No. 1 is made zero (as by the use of a regulation corrector) then when it is necessary to start No. 2, No. 2 may be set and operated at a constant load of full load and all additional load changes will automatically be absorbed by No. 1. In this way, proper correlation of governors on various units may do much to secure automatic satisfaction of loads in the most economical manner.

Utilities Major Turbine Customer

PRIVATE UTILITIES still account for about 88 per cent of all the turbine generators bought in this country, and most of them purchased during the past year were of the new hydrogen-cooled type, according to a survey of large unit purchases made by W. E. Blowney, turbine engineer for the General Electric Company. Blowney's study was based on his company's sales of turbine generators rated 10,000 kilowatts and above, exclusive of those for marine propulsion, during the two four-year periods 1926-29 and 1935-38.

The survey revealed that industries and municipalities bought an increased percentage of turbines in the 1935-38 period than they did in the years 1926 through 1929, but that their share represented only a small part of the total volume.

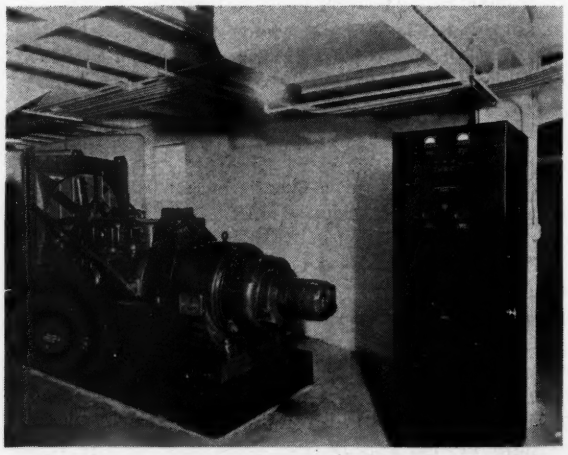
A marked swing toward the hydrogen-cooled type turbine-generator during the past few years was disclosed. Units of this type are capable of operating more efficiently in large sizes and higher speeds. Although orders for hydrogen-cooled units had been placed as early as 1935, the first one was not in operation until October, 1937, at Dayton, Ohio. One year from that time hydrogen-cooled turbine-generators representing a total generating power of more than 400,000 kilowatts had been installed by General Electric and were in actual operation.

The average rating of the 1800 r.p.m. turbines sold during the 1935-38 period was 20,000 kilowatts more than that of the units sold during the earlier period, which had been looked upon as the era of the large turbine. Further, the average rating for the higher-speed 3600 r.p.m. turbines sold during the four-year period just ended was double the maximum of units of the same speed purchased in the years 1926-29. Average size of all turbines considered in the study was found to be almost exactly the same for the two periods. The earlier period average was 35,300 kw.; the later period 35,200 kw.

Substantial increases in initial steam temperatures for units bought during the past 4 yr. were attributed to a better understanding of the properties of alloy steels. The study further showed that the use of higher initial steam temperatures of 900-950 deg. F. had reduced moisture content thereby permitting simplification in turbine designs. Present-day higher temperatures have obviated the need for the resuperheating necessary with the 700-750 deg. F. temperatures popular in the 1920's, according to the study, but recent orders calling for still higher pressures indicate that resuperheating will again be required for those units.

Engines for Broadcast Standby

NEED FOR a dependable and readily available source of standby power prompted the installation of a Bardco 80 kv-a. electric unit in Radio Station KNX at Torrance, Calif. Stop-watch timing at the plant before installation and at the transmitter subsequent to installation indicated a 4.5 sec. time interval from cold start to full speed and voltage. During a recent broadcast of election returns the standby unit was



Tests show standby units of this kind can be brought to full speed and voltage in 4.5 sec.

used from midnight until 2:00 A. M. for the regular broadcast of the station and a double changeover from utility to standby generation was accomplished with no detectable interruption. A similar unit of 25 kw. capacity will be installed by Columbia at its studio building on Sunset Boulevard in Hollywood. The generator in the above installation is a Master 80 kv-a., 2300 v., 3 phase, 50 cycle unit, driven at 1500 r.p.m. through a flexible coupling by a 935 cu. in. displacement 165 hp. Hercules 6 cyl. gasoline engine with a 5¾ in. bore and a 6 in. stroke.

Increasing domestic and industrial load on the Grand Haven, Mich., Municipal system met by the installation of a 2250 hp. Diesel unit in a plant extension at a total cost of approximately $200,000. Total capacity now 2850 kw. in Diesels and 4000 kw. in steam standby.

Grand Haven Grows

SINCE 1896, when a $10,000 bond issue was used to build a small steam plant and distribution system, electric light and power has been supplied to Grand Haven, Mich., by a municipal power plant. By 1925 the capacity of the plant had increased to 3000 kw. An offer of $1,200,000 by a private company was rejected by election in 1930 and to take care of the increasing load a new Diesel plant was built adjacent to the steam plant at a cost of $217,000. Two 4 cycle, 1150 hp., 0.8 p.f., 800 kw. units were installed and the steam plant was retained for supplementary service.

In spite of the depression the load continued to increase and $82,000 was spent in 1934 for a third 800 kw. unit and alterations to the building. Three years later the building was extended to provide space for two more units, although only one unit, a 2250 hp., 2 cycle Nordberg, driving a 1600 kw. generator, was installed. The total cost, including a new water intake and pump house, was approximately $219,000.

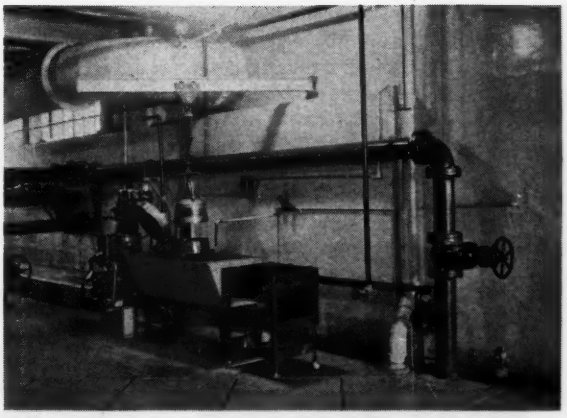


Fig. 2. One of the many conveniences installed in the plant to facilitate operating and maintenance routine. With this chain block, mounted on a swinging bracket, cleaning the fuel centrifuge is made easy. The swinging drop pipe is for kerosene piped from an overhead tank

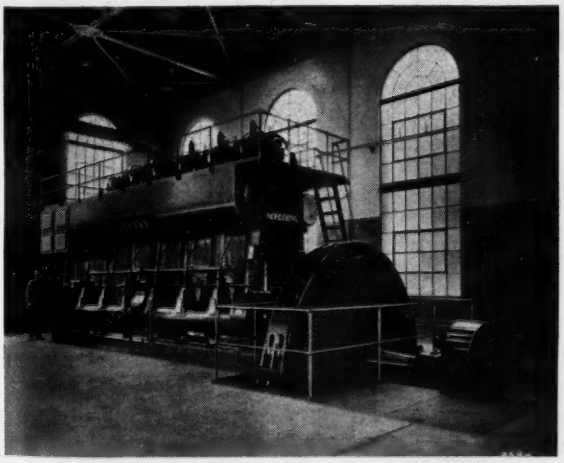


Fig. 1. This new 2250 hp. Nordberg Diesel drives a 1600 kw. generator and because of its higher efficiency carries base load

The plant is ideally located with ample cooling water and facilities for fuel delivery by truck, rail or barge. At present Michigan fuel is used and this year the fuel storage facilities were doubled by the installation of a 100,000 gal. underground tank. A contract was recently let for an additional 150,000 gal. tank which will give a total of 350,000 gal. storage capacity.

All improvements and extensions, including the original plant, have been paid for from operating profits, this over and above the money turned over to the general fund of the city. Since 1930 the power and light system has been administered by a Board of Public Works of which J. Bryan Sims is superintendent. Hamilton & Weber of Grand Rapids, Mich., acted as consulting engineers.

Eliminating Engine Exhaust Noises —A New Approach and a Universal Solution

MUFFLING internal combustion engine exhaust, and closely related to this, compressor and blower intakes, has long been a problem which, due to the increasing use of automotive and Diesel engines in congested commercial industrial and residential areas, has of recent years become serious. In general efforts along this line have been directed toward the use of: throttling or baffling which, if effective, may introduce undesirable back pressures; sound absorbing chambers which are apt to be excessively large; or, resonators, etc., based on established acoustic theory and which must not only be tuned to each individual job and frequency but used in a definite position so that the engineering cost is high, with efficiencies often impaired by restricted installation conditions or with the engine operating at variable speeds.

To find universal application a silencing device for this service must: be effective over a wide range of gas flow or loading; be of small size and untuned so that it is capable of quantity production, of installation in any position in the exhaust line in limited space and be effective over a wide range of engine speeds; have no adverse effect on engine operation or, if possible, correct bad conditions sometimes introduced by the natural characteristics of exhaust lines.

This last is brought about by the momentum or ramming effect set up by a rapidly moving column of air stopped suddenly by the closure of a valve or reversal of pressure in some part of the system. Its importance has long been recognized by engine designers who give careful attention to intake and exhaust manifolds so as to neutralize, or, in some cases even take advantage of the effect.

In the intake manifold card of Fig. 3, Point A shows how the air in the manifold, accelerated during the suction stroke, builds up a pressure in excess of atmospheric after the inlet valve is closed. In a two cycle port scavening engine the effect is more pronounced because of the sudden closing of the port without the gradual deceleration of the flow in synchronism with the piston speed.

Due to the sudden release of the slug of exhaust gas from the cylinder under comparatively high pressures, and other factors which will be discussed later, pressure surges in the exhaust system are more violent than in the intake manifold. As shown by Stroke 4 of Fig. 3 these fluctuations are reflected in the cylinder pressure because the exhaust valve is open during the entire stroke. In fact, at the beginning of the suction stroke the cylinder pressure, as shown by point E, was considerably above the inlet manifold pressure due primarily to the exhaust from another cylinder.

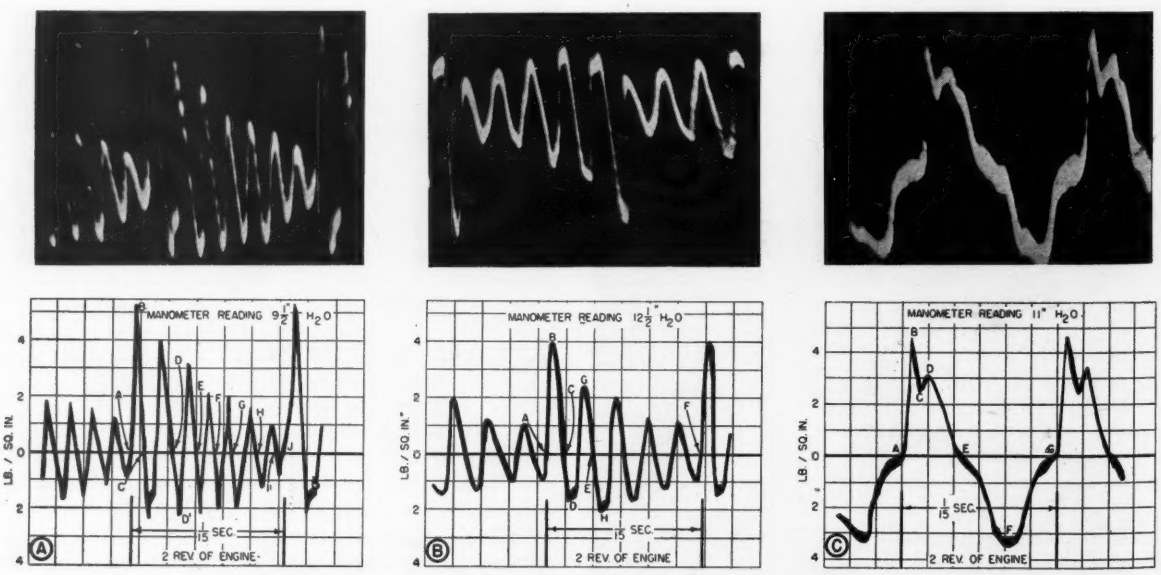


Fig. 1. Oscillographs taken from a full loaded, four cycle, single cylinder gasoline engine operating at 1800 r.p.m.

No muffler was used but the length of the exhaust pipe was varied. In A the exhaust pipe was 32 in.; in B, 49 in.; and in C, 19 ft. (288 in.). The initial pressure peak is caused by the slug of exhaust gases from the cylinder, which travels through the pipe at a velocity close to or above that of sound. This is followed by a series of damped pressure waves caused by the inrush of air to the pipe following partial evacuation by the sudden passage of the exhaust gas slug. The frequency of these waves is a function of the length of the exhaust pipe which acts similar to an organ pipe with the closed end at the engine. The oscillographs check closely with calculations even without temperature corrections. Card C, taken with a 19 ft. exhaust pipe, shows no pressure waves because this is the resonant length for 15 cycles corresponding to the frequency of firing of the engine. Manometer and oscilloscope readings were taken close to the engine.

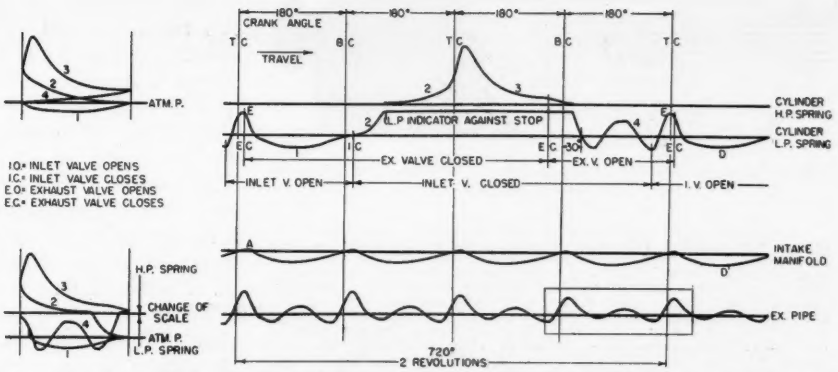


Fig. 3. Combination high and low pressure indicator cards for a single cylinder of a four cycle, four cylinder gasoline engine and drawn by a Research direct pressure indicator developed by the Commercial Engineering Laboratories

The intake and exhaust cards reflect the combined action of all four cylinders, the horizontal lines represent atmospheric pressure in each of the four diagrams. The four strokes, 1, suction, 2, compression, 3, power, and, 4, exhaust are marked on the two top cards and with corresponding numbers on the conventional card shown in the small sketch in the upper left hand corner. The small card in the lower left hand corner is a similar card reproduced from the diagrams at the right, but with the four strokes superimposed so as to show the variation in actual and ideal performance. These pressure-time diagrams are distorted from the usual pressure-volume diagrams because the drum moves at constant velocity and not in synchronism with the piston. During the exhaust stroke, 4, the exhaust valves are open and pressure fluctuations in the exhaust pipe are reflected in the engine cylinder. The section of exhaust diagram outlined by a rectangle corresponds roughly with the oscillographs shown by Figs. 1 and 2. In extreme cases pressure fluctuations in the exhaust manifold of two cycle engines are, while both exhaust and scavenging ports are uncovered, reflected through to the scavening air manifold and seriously impair engine operation as shown by Fig. 5.

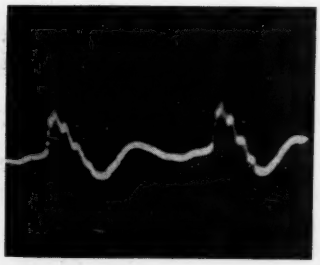
Inasmuch as the inlet valve is open during this peak pressure E there is a tendency for exhaust gases to flow into the inlet manifold and contaminate the air supply intended for combustion. This condition can be controlled only within narrow limits[1] by valve setting as it depends primarily upon the natural characteristics of the exhaust system and the effect of the other cylinders.

Pressure fluctuations in the exhaust pipe of what may be considered a typical engine is shown by the bottom diagram of Fig. 3. The rectangle represents conditions between two consecutive explosions and in so far as a multi-cylinder engine can be compared with a single cylinder engine, approximate conditions represented by Figs. 1 and 2. These four oscillographs were taken by the Acoustic Division of the Burgess Battery Co. in its research laboratories at Chicago during the development period of a new silencing device since named the Burgess Snubber.[2]

Engineers of the company, long a leading manufacturer of acoustic silencers, found it difficult to account for occasional field experiences by means of the commonly accepted acoustic theories. Certain silencers (and the engines with which they were used) performed much differently from others operating under seemingly identical conditions. As a result they embarked on a research program, which extending over a period of more than 2 yr., resulted in the development of a new theory.

Realizing the inadequacy of conventional instruments for this purpose, the first step was the acquisition of a cathode ray oscillograph using a specially developed piezo-electric pressure sensitive element. Rochelle salt crystals, like quartz, will, when properly cut, mounted and subjected to pressure, develop an electrostatic force proportional to the pressure. This amplified and used in conjunction with the sweep circuit of the oscillograph makes it possible to obtain calibrated pressure-time diagrams. The pressure element of this instrument was connected to the exhaust pipe as close to the engine as possible.

Four of the oscillographs, and the corresponding developed diagrams, are shown by Figs. 1 and 2. They were taken from the test engine under the conditions outlined in the captions. As a result of the studies it was found that the exhaust noise consisted of two parts: a sharp explosion caused by the sudden emission at high velocity of an initial slug of exhaust gas from the exhaust or tail pipe at each engine explosion; and a higher frequency, sustained but damped, tonal sound of lower amplitude caused by the free oscillation of the column of gases in the pipe.



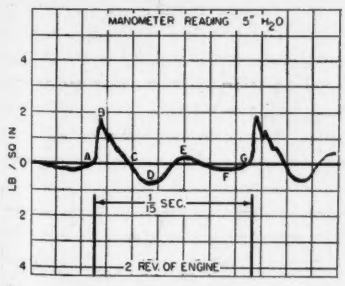


Fig. 2. Oscillograph with a Snubber

This is from the same engine under the same operating conditions but using a double Snubber at the end of 11 in. of exhaust pipe to give a total length of 32 in., so as to be directly comparable with Fig. 1A. Notice that the pressure waves between slugs have been almost entirely suppressed, the peak pressures reduced more than 50 per cent over operation without the Snubber, and the manometer readings reduced 45 to 60 per cent.

The action of the snubber as analyzed from the curves is as follows. The slug enters the closed end of the system at A and the pressure rises to B. Some of the slug passes out of the exhaust end of the snubber and the gas remaining cools and contracts, setting up a negative pressure in the closed end of the pipe shown at D. Air then flows into the exhaust line to balance the pressure, and at E, the inertia of the inflowing air causes a slight increase in pressure above atmosphere. Air flows out of the snubber again at F and at G the exhaust valve opens again. The exhaust sound is a soft "puff" with no further impacts with the atmosphere to cause a sustained sound till the following exhaust occurred.

[1]See Fig. 12 of Indicating the High Speed Diesel by E. T. Vincent, POWER PLANT ENGINEERING, page 746, December, 1937. This tells how a peak similar to E of Fig. 3 above was shifted by retiming the valves so as to increase the volumetric efficiency of the cylinder from 81.6 to 89.8 per cent.

[2]The development and testing of this device was carried on largely by Ralph L. Leadbetter, John A. Marquardt and Alfred S. Chipley.

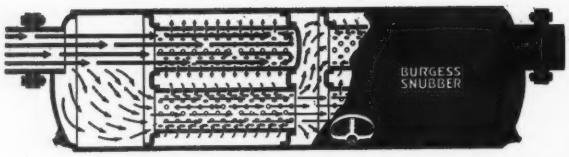


Fig. 4. Sectional drawing of the Snubber with arrows indicating the direction of gas flow

The initial high velocity gas slug discharges directly to the closed end snubber tube and vents gradually through the perforations in the exhaust tube to the second stage. This is similar to the first stage but with the position of the impuls and vent tubes reversed. Slower moving gases from the inlet pass directly to the first stage vent tube as indicated by the arrows. The distance from the inlet to the snubber tube is not critical but in practice is made about twice the diameter of the inlet. Experience has indicated that a shorter distance causes heating and a greater distance adds nothing to performance. Performance of the snubber from the standpoint of noise elimination is not critical and is equally effective over a wide range of gas flow. Commercial sizing is based on a total snubber volume 10 times the volume of the slug exhausted from each cylinder, that is, approximately the cylinder volume at exhaust corrected to average exhaust pipe pressure and temperature conditions.

The slug of exhaust gas leaving at high velocity draws a vacuum and the atmosphere surging in sets up a pulsation or secondary vibration which is visible in the first two oscillographs. The frequency of this secondary wave is determined by the length of the exhaust pipe.

A four cycle single cylinder engine fires once every two revolutions, or at 1800 r.p.m., 15 times a second; so the exhaust pipe length for resonance is 19 ft. The oscillograph taken with this length exhaust pipe is shown by Fig. 1C. Here the pressure rise caused by the insurging air is picked up by the exhaust slug of the succeeding explosion.

The velocity with which the wave front of this slug travels is indicated by the almost vertical rise of the oscillograph ray from A to B in Fig. 1 and by the fact that it travels some 5 diameters beyond the end of the exhaust pipe before it begins to flare out. The new Snubber, Fig. 4, utilizes this fact and is arranged so that the slug discharges directly across a gap into a closed end snubber tube from which the name is derived. This tube is perforated, and, the instant pressure built up forces the gas into the first chamber surrounding the tube. At this stage in the cycle pressure rises in the entire front section of the tube and gases entering at lower velocities are by-passed direct to the exhaust tube along with the cross leakage direct from the snubber tube through the perforations. The driving force which causes the gas column to oscillate is absorbed by the high impedance of the snubber tube.

To preclude the possibility of a resonant condition arising, and, to absorb any residual velocity from the exhaust tube, a second snubber section is casconaded with the first, thus introducing a time delay. This second section is the same as the first, but with the two tubes reversed so that the first exhaust tube is directly opposite the second snubber tube and the second exhaust tube opposite the discharge opening.

Figure 2 shows the action of the snubber used with 11 in. of exhaust pipe to give a total exhaust system length of 32 in. directly comparable with Fig. 1A. It is interesting to note that the peak pressures with a plain exhaust pipe range from 4 to almost 5 lb. per sq. in. or more and the average pressure as measured by the manometer ranged from 9½ to 12½ in. of water (1 lb. per sq. in. equals 27.7 in. of water). With the Snubber, peak pressures were reduced to about 2 lb. and the manometer reading to about 5 in. of water.

The Snubber may be placed at any convenient point in the exhaust line. Tests made with the device close to the outlet of a relatively slow running engine of large piston displacement show a lower manometer reading than with an equal length of exhaust pipe and gas temperatures[3] were lowered. On a 3 cyl. 14 by 17 in., 2 cycle Diesel a resonator baffle type muffler, installed directly on the exhaust manifold with only a short tail pipe, was not entirely satisfactory, although the back pressure was negative. A Snubber replaced it, the back pressure increased to 1½ in., but the engine temperature dropped 30 deg. F. and silencing was excellent. More complete data on another engine is shown by Fig. 5.

EDITOR'S NOTE: Due to the necessity for brevity and a more detailed explanation of the practical features of this device it was not possible to give a full explanation of the oscillographs and complete development of the theory. Complete mimeographed reports are available, however, and will be sent to those interested in following the technical details more closely. Address requests to the Engineering Editor.

Pressure drop is of course a function of the loading or gas velocity. Seven tests made on four size units with a positive blower showed the pressure to vary as the square of the velocity based on the intake size. Points for all sizes, plotted on logarithmic paper, fell on a line running from 1 in. of water pressure drop at 2100 f.p.m. to 83 in. at 20,000 f.p.m.

Three different sizes units tested on a 6 cyl., 4 cycle, 5¾ by 9 in., 1200 r.p.m. Diesel fell on a line running from 1 in. at 2300 f.p.m. to 100 in. at 17,775 f.p.m., or with the pressure loss varying approximately as $V^{2.27}$. Gas velocities were calculated from volumetric efficiencies, with corrections for pressure and temperatures. Tests on a Mack truck showed the back pressure with a Snubber to range from 1 in. at 600 r.p.m. to 2.7 in. at 2200 r.p.m. as compared to 0.5 in. and 4.6 in. respectively with a cast iron pot type baffle muffler. Test

(Continued on page 194)

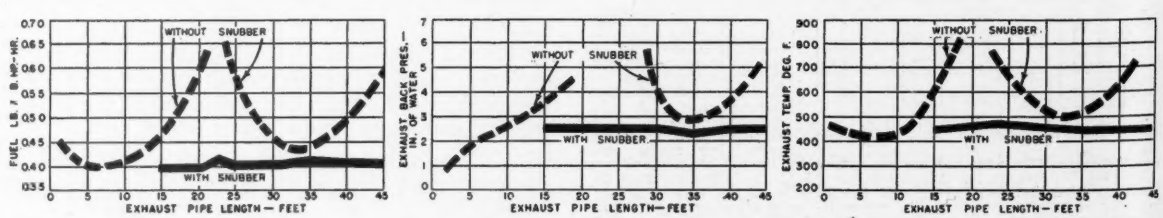


Fig. 5. Charts showing the effect of exhaust pipe length, with and without the use of a Snubber, on the performance of a 60 hp., 450 r.p.m., 2 cyl. Diesel engine under full load operation

Part XXXIV

Further considerations of electron tube motor control circuits. Systems for maintaining constant speed, constant armature voltage, constant field voltage or to control a motor as some function of either direct or alternating voltage—all systems utilizing electrical feed back methods.

ELECTRON TUBES— Principles and Applications

By A. W. KRAMER

THE THYRATRON TUBE CIRCUITS utilizing mechanical feed back described in the preceding chapter as pointed out have been found very useful in applications where it is necessary to vary the motor speed in relation to certain mechanical operations, such as wire drawing, the making of celluloid, rubber and rubber fabrics.

There are, however, other cases involving motor control where it is desirable to maintain constant speed, constant armature voltage, constant field voltage, or to control a motor as some function of either a direct or alternating current voltage, or to maintain approximate synchronism between two different systems by means of pilot generators. Pilot generators are small generators mounted on the shafts of driving motors or driven machines which generate a voltage or frequency directly proportional to the speed of the shaft on which they are mounted, the output voltage being used for control purposes only.

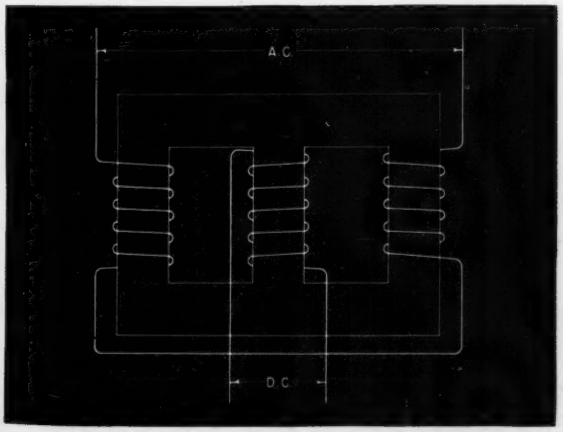


Fig. 1. A diagram showing the windings of a saturable core reactor

Use of Saturable Core Reactors

As was the case with the mechanical feed back systems, a number of such electrical feed-back circuits using thyratrons have been developed by the General Electric Co. and were described in the A.I.E.E. paper previously referred to.[1] In these circuits a small saturable reactor is used in place of the solenoid type reactor used in the mechanical feed-back circuits. A saturable core reactor is a reactor with two windings, one the alternating current winding and the other a direct current winding. The reactance to the flow of alternating current through this winding is a function of the degree of magnetic saturation of the core which in turn is dependent upon the amount of direct current passing through the direct current coil.

For use in these control circuits a suitable reactor is one in which a change from zero to three milliamperes in the direct current winding will vary the reactance of the alternating current winding from one to 10,000 ohms. If the two halves of the alternating current winding are connected in series, this change in reactance can be obtained within a few cycles referred to a 60 cycle supply.

[1]Thyratron Control of D.C. Motors by G. W. Garman. Presented at the winter meeting of the A.I.E.E. in New York, January, 1938.

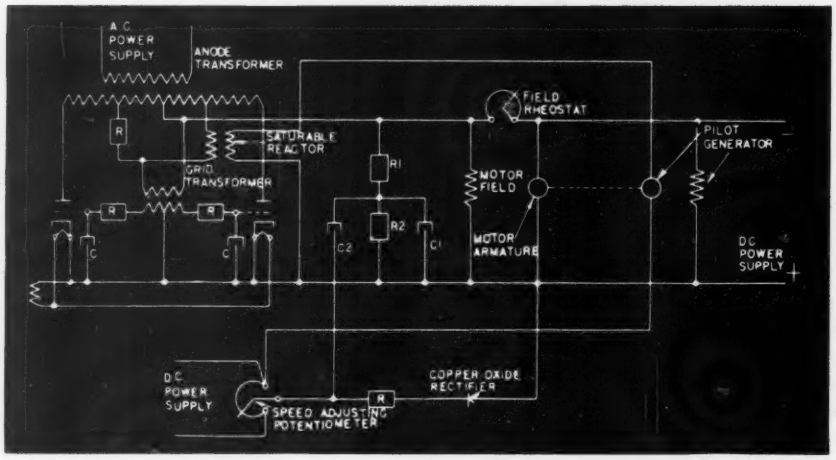


Fig. 2. A circuit for holding constant motor speed using thyratron field control

A thyratron motor control circuit utilizing such a saturable reactor and designed to hold constant motor speed by means of field control is shown in Fig. 2. As shown, the speed determining means is a pilot generator and the standard of reference is the voltage drop in the potentiometer.

Under conditions of normal operation the voltage of the pilot generator will be slightly greater than the voltage obtained from the potentiometer.

With an increase of load on the motor the speed will tend to decrease and as a consequence the voltage of the pilot generator will decrease. This in turn decreases the current through the direct current winding of the saturable reactor. Such a reduction in the saturation current of the reactor increases its reactance to the flow of alternating current and as a consequence the output voltage of the thyratron will decrease. This lowers the field voltage, thereby restoring the speed of the motor to its previous value.

If the load on the motor is decreased the accompanying rise in speed will have the opposite effect. The pilot generator voltage will increase causing an increase in the saturation current and a corresponding increase in the thyratron output voltage.

In either case, the speed will never be restored to exactly the previous value when a change in load occurs because there must always be a change in the relative voltages of the pilot generators and the potentiometer in order to produce the required change in saturating current. With a correctly designed saturable reactor, a small voltage when impressed on the direct current winding is sufficient to vary the thyratron current from zero to maximum. By adjusting the arm of the potentiometer the speed of the motor can be held constant within a few per cent from no load to full load over its entire speed range as shown in Fig. 3. These curves, it will be seen, indicate that the change in speed from no load to full load for the lowest range was between 5 and 6 per cent. This abnormal change was due to the fact that the thyratron output voltage was near its maximum value.

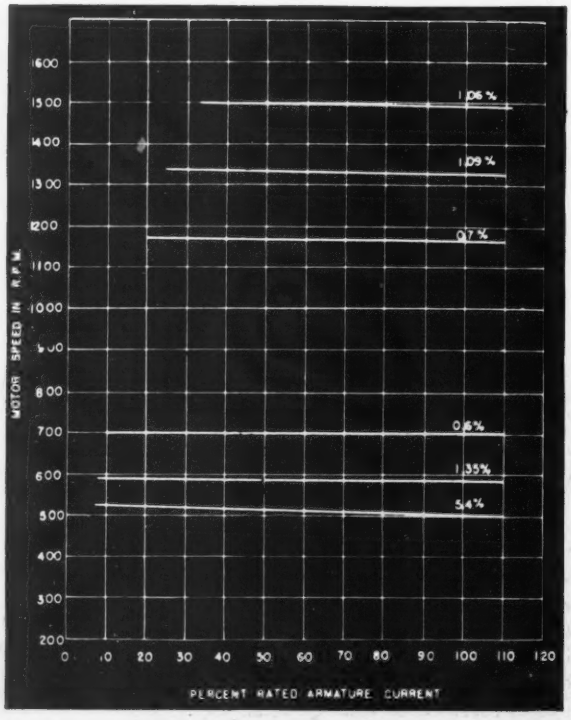


Fig. 3. Curves showing the performance of the field control circuit in Fig. 2. The curves show speed regulations for different speed settings

The direct current voltage for the speed adjusting potentiometer may be obtained either from a suitable direct current voltage source or from the voltage of another pilot generator connected to another system. In this way the relative speed of two independent systems can be held approximately constant.

Field and Armature Control

The circuit in Fig. 2 is for field control. There are, however, certain processes where a wide range of speed control is required in which the speed variation from no load to full load is a minimum. Such requirements are fulfilled by the circuit shown in Fig. 4 which involves armature control.

As pointed out in Mr. Garman's paper in which

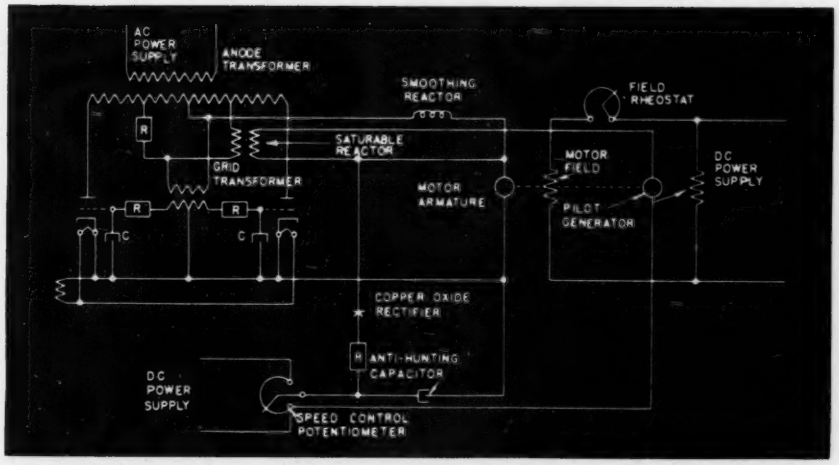


Fig. 4. A circuit using thyratron armature control for holding constant speed

these circuits were first described, these circuits have been used for controlling the speed of high-frequency generators and conveyor systems and probably are applicable to many other similar uses.

Where an adjustable speed control system is required the circuit shown in Fig. 5 is interesting since it incorporates an adjustable source of power for the armature and excitation for the field. The control circuit is essentially the same as that shown in Fig. 4 except that the voltage applied to the speed control potentiometer is obtained from the field circuit.

Elimination of Hunting

In any of these feed-back systems, mechanical or electrical, hunting may be caused by time delay in either the control or controlled circuit. A common method of eliminating hunting is to slow the response of the control circuit sufficiently to allow the circuit being controlled to respond to the new condition. Slow speed feed-back systems are inherently stable but in high-speed systems it may be necessary to either decrease the rate of response or to provide an anti-hunting circuit.

One method of eliminating hunting in electrical feed-back circuits is to feed back into the control circuit, a voltage which is proportional to the rate of change of one of the circuit voltages. Such a voltage can be obtained by means of the condenser discharge principle discussed in earlier chapters[2] and used so effectively in electronic voltage regulators. It is accomplished by impressing one of the circuit voltages on a resistor capacitor circuit in which the voltage drop in the resistor varies as a function of the rate of change of the applied voltage. These resistor-capacitor combinations will be noted are connected across several of the circuit diagrams.

In the motor control circuits considered thus far the problem is primarily that of either maintaining a definite speed relationship between two systems or of maintaining constant motor speed. Now we come to a third general classification in which a direct current motor is controlled as a function of either an alternating voltage or a continuous voltage which is dependent upon the position or speed of the motor. As pointed out by Mr. Garman in his discussion of these controls, the control of an arc furnace or an automatic arc welding head fall into this class. The problem in either case is to maintain constant either the arc voltage or the arc current.

A circuit developed for this kind of control is shown in Fig. 6. It was developed for either automatic or metallic arc welding. In this application a small direct current motor is used to feed the electrode

[2]Part XXIX September, 1938, p. 576.

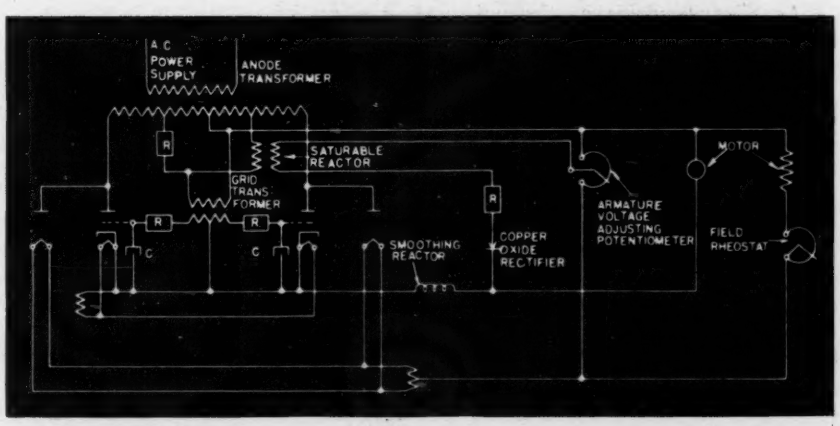


Fig. 5. Thyratron armature control circuit for holding constant armature voltage

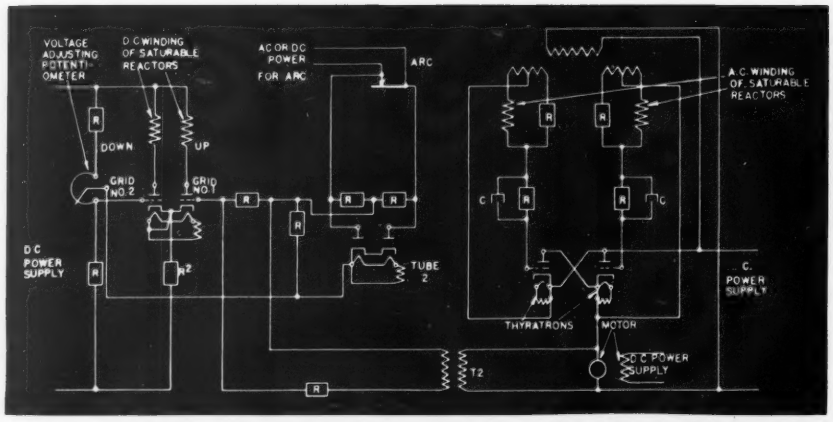


Fig. 6. Thyratron control for reversing direct current motor—atomic or metallic arc welding control

wire to the arc. Since the motor is small only two thyratrons are required to run the motor in either direction.

The two small saturable reactors shown in this circuit are used to control the two thyratrons. With equal saturation in the two reactors each thyratron will pass the same amount of current but of opposite polarity. In this case the average value of the torque in the motor will be zero. If the saturation of one reactor is greater than that of the other, the motor will run in one direction at a speed determined by the difference in saturation. Conversely, if the saturation is in the reverse order, the motor will run in the opposite direction. The saturation current is controlled by means of a duo-triode which has two anodes, two grids and a common cathode.

Normally, the arc voltage, either alternating or direct, is rectified by means of tube 2 and impressed on grid number 1 of the duo-triode. If the arc voltage is above normal, as determined by the setting of voltage adjusting potentiometer, the saturating current through the "up" reactor will decrease, thereby reducing the current through the "up" thyratron with the result that the motor armature will run in the down direction. The accompanying reduction in current through resistor R2 increases the bias on the grid number 2 in a positive direction tending to still further saturate the "down" reactor. If the arc voltage is low the "up" reactor will become saturated and the motor will run in the reverse direction.

As a consequence of the unbalancing effect of resistor R2 a variation of several per cent in the arc voltage is sufficient to cause the motor armature to run at full speed in either direction. In atomic arc welding the electrodes burn away so slowly that the motor armature normally stands still. In metallic arc welding the welding electrode burns away much faster and in normal operation the armature gradually turns in the downward direction, but can if necessary run from zero to full speed in either direction. The circuit will respond to a change in arc voltage within a few cycles referred to a 60 cycle source.

It will be obvious from the foregoing description and discussion of these circuits that the thyratron is an extremely useful device in making possible sensitive and accurate control systems.

The principle of phase control made use of in these circuits overcomes the inherent limitations of the three element gas filled tube as compared to the three element high vacuum tube and gives it a definite place in heavy power applications. In the past, cost of control and lack of confidence have been limiting factors in the application of thyratrons to the control of direct current motors but these factors are gradually being changed. Experience has already indicated that confidence in this type of control is increasing and with increased use the costs will be brought down. Larger units also will be developed to meet the requirements of higher powers as time goes on.

Eliminating Engine Exhaust Noises

(Continued from page 190)

points, when plotted on rectangular coordinates, are scattered somewhat, but fall reasonably close to a straight line between the extremes mentioned.

Because the snubber is designed around the individual slug of exhaust gas it is as effective on multi-cylinder as on single cylinder engines, but the size for a given engine rating is smaller for multi-cylinder units. The commercial sizes, now available in a complete range, appproximate in total volume 10 times the volume of an individual exhaust slug corrected to average pressures and temperatures.[3]

Inasmuch as the problem of exhaust silencing is closely related to that of silencing the intake on engines, compressors and blowers, the same device is equally effective there, and to extend its usefulness still further, it has been found to be an effective spark arrester.

The Snubber, on which patents have been applied for, is legally an invention, but in reality it is a development based on modern research methods. The problem was analyzed by means of adequate instruments, reduced to fundamentals and solved by the application of scientific principles aided by a background of experience. It is an excellent example of the part that research can, and is, playing in the solution of every day practical engineering problems.

[3]Such temperatures, as in the case of manometer readings, indicate an average condition, and although they serve as a readily duplicated and valuable reference point and an invaluable guide to operation, probably give little indication of the actual temperature of the gases leaving the cylinder for at times flame will be discharged through the exhaust port or valve.

With a registered attendance of 1585 the Annual Winter Convention of the American Institute of Electrical Engineers held in New York January 23-27 was the largest in 8 years. Seventy-six technical papers formed the basis of the technical program.

A. I. E. E. Winter Convention Largest Since 1931

IF ALL THE BRAIN POWER that went into the production of the seventy-six technical papers that were presented at the Annual Winter Convention of the American Institute of Electrical Engineers held in New York during the week of January 23 could have been converted into knowledge of a different order by a mental energy converter of some sort it is quite likely that many of the social and economic problems which beset us at the present time would vanish.

The amount of high grade mental energy represented in the technical subject matter of a convention of this kind is truly prodigious and this particular meeting was no exception to the rule. The technical subjects considered involve practically the entire range of physics and mathematics together with the knowledge of materials and processes evolved through centuries of scientific effort and learning; many of the papers, indeed, are so complex that only those specializing in the respected branches of the art are capable of discussing them.

As in other branches of human endeavor the art or science of electrical engineering has grown to such an extent that it is too vast for any single individual to understand more than a small portion of it. As a matter of fact, many, if not the major portion of those attending these conventions, are specialists of one kind or another and, naturally, are interested primarily in papers or sessions involving their own branch of the field. That is the reason for having simultaneous sessions. The power transmission engineer, for example, is vitally concerned with papers presented at the power transmission session but exhibits only a cursory interest in the sessions on communications. For the same reason, the communication engineer who delights in the intricacies of telephone switching systems is not greatly concerned about the latest developments in high speed relaying practice disclosed at the transmission sessions.

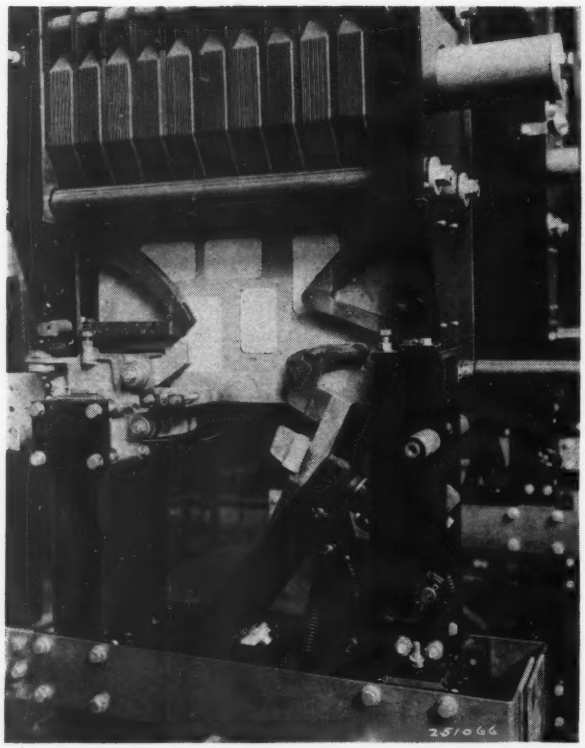
From the standpoint of the specialists there is therefore much to commend in the practice of holding simultaneous sessions but it works hardship upon the well-meaning editor of a technical publication endeavoring to cover the convention as a whole. For aside from his sheer inability to make himself ubiquitous, the practice of holding simultaneous sessions tends to increase the degree of specialization of the papers.

The cable engineer or the electrical machine designer or the transmission engineer each have their respective interests and to that degree the convention satisfies their needs but the poor editor who after all does not know very much about anything[1] is assumed to know all about everything. He goes to the meeting with the object of bringing back a word picture of the convention so that the readers of his publication will know what happened. His job simply is to condense the abstruse and complex material contained in 76 voluminous technical papers into an easily read 4 page report so that his readers may read as they run.

Quite obviously this is difficult, in fact impossible and in the limited space available we shall make no attempt to do this; we shall make no attempt to discuss the subject matter of the papers in any degree of detail. Rather, we shall endeavor to present a broad view of the convention—a picture which will portray to some extent the condition of the field as a whole and show what electrical engineers are doing and what they are concerned with.

One thing which impresses us at these meetings is that apparently no problem or need that arises is too difficult to solve. Regardless of how complex, no

[1] Though he never admits it.



New high power air breaker described at the Protective Devices Session by R. C. Dickenson of Westinghouse. Rated at 15 kv., 3000 amp. continuous, this breaker has interrupted currents of 37,000 amp. repeatedly

matter how involved the problem, given sufficient time, engineering and research today seems able to find the answer.

Circuit Interruption and System Protection

A decade ago, one of the major problems in the electric power industry was that of circuit interruptions. Advanced as they were, the circuit breakers of ten years ago were hopelessly inadequate to meet the growing requirements of system operation, furthermore they were large, expensive and cumbersome. These thoughts came to mind as we sat in on the session on protective devices at this meeting and learned about the characteristics of the latest types of oil and air circuit breakers—breakers which approach in performance the fastest high voltage breakers in the world but at a cost of much less than the fastest. These multiple unit "De-ion" grid breakers have their origin in Dr. Slepian's theory of de-ionization first disclosed at one of the winter conventions less than ten years ago. These new grid contacts and auxiliary mechanisms were placed in the tank of a ten-year old type of breaker and then subjected single phase to ground fault currents of as much as 6000 amp. at 220 kv. corresponding to 2,250,000 kv-a. on a three phase basis. At a frequency of 50 cycles per sec. the average interrupting time was 2.6 cycles.

While this does not imply that all circuit interruption problems have been solved, it does indicate that sufficient knowledge of fundamentals has enabled us to meet our requirements as they grow for today breakers of this order of performance in conjunction with modern relay systems are capable of meeting the needs of our longest and highest voltage systems to a high degree.

At this same session on protective devices where the details and operating characteristics of these multiple grid De-ion breakers were disclosed, two other papers dealt with new high capacity air circuit breakers also of the De-ion type. One of these involved 15 kv. multiplase air breakers—the largest air circuit breakers in the world. Described by R. C. Dickinson of Westinghouse, this breaker has a continuous rating of 3000 amp, and during routine tests has interrupted 37,000 amp. (half a million kv-a.) on a single pole and has closed against peak currents of more than 100,000 amp.

Mr. Dickinson stated that after a series of 21 tests in rapid sequence at high currents, which is equivalent to many years of central station service, the circuit breaker was dismantled for inspection, was found to require no repairs or replacement of parts and was reassembled to be put through another series of gruelling tests.

Relays

As implied in the foregoing consideration of circuit breaker development, relay practice is closely associated with the circuit breaker art. This is so because the circuit breaker is usually the terminus of the sequence of events set in operation by a fault with the relay system as its channel of transmission. A high speed circuit breaker is of little use unless the relay system has similar speed characteristics. About 1930 manufacturers introduced the high speed circuit breaker with an operating speed of about 8 cycles and at the same time engineers awoke to the possibilities of high speed or one cycle relays. In view of almost ten years' experience with relays of this type it seemed desirable to present a review of this experience and to that end the Relay Subcommittee of the A.I.E.E. Protective Devices Committee presented a report at this convention. This report presented at the session on relays indicated that while the ideal relay scheme so earnestly sought after has not been found, the efforts made in that direction have not been in vain.

This report showed that the instantaneous overcurrent relay, despite the development of other types, provides a simple inexpensive means of obtaining high speed relay protection over a considerable portion of the line length and offers possibilities in the way of system improvement of which full advantage has not been taken. Distance relays have proved themselves reliable if carefully applied and maintained and are widely used. Carrier current or metallic pilot protection appears to be the first choice of high speed protective systems whenever the expense is justified.

The whole question of relays and relaying is complex and involved and the proper application of relays requires a wide knowledge of all aspects of transmission systems, particularly with reference to transients. The question of high speed bus protection for example can be successfully solved only if proper steps are taken to prevent the operation of the differential relays on transients. This particular aspect of relay operation was presented in another Relay

Subcommittee report at the relay session. The recent occurrences of several serious switchboard fires created considerable interest in this subject and the report was based on data regarding bus protective schemes from 34 companies.

The question of relaying was also touched upon in the paper at the "Transportation" session by E. L. Harder of Westinghouse who described what was termed the fastest fault clearing system in the world for heavy power systems. This is the system used on the newly electrified New York-Washington-Harrisburg section of the Pennsylvania R. R. On this system a fault can be cleared in a total of 0.04 second. One feature of particular interest regarding this system is that the relays are so "intelligent" that they will clear a fault current that is less than the maximum load current of the line. The locomotives and cars on the system do not have main circuit breakers; major faults on the moving equipment are cleared at the substation by the opening of the trolley circuit.

Switch House Modernization

The recent fires in switchhouses referred to above, in addition to stimulating interest in high speed relaying for bus protection has also directed attention to the design of the switch house itself and practically the entire power generation session was devoted to this question. Each of the four papers presented at this session dealt with the reconstruction or modernization of large switch houses. Two of these were specific cases, that involving the L Street Station switch house in Boston and the other the switching facilities at Eessex Station of the Public Service Electric and Gas Co.

The two remaining papers dealt with the subject generally, one being presented by A. M. de Bellis of the Consolidated Edison Co. of New York and the other by H. E. Strang and W. H. Hanna, both of the General Electric Co.

These papers naturally were concerned with modernization not with history, but it was disappointing, in view of the disastrous Hell Gate switch house fire of January 1936 that Mr. de Bellis' paper gave practically no reference to that event.

In the case of the New England hurricane last September, the convention devoted the entire last session to a discussion of that disaster from the standpoint of the public utility services, i.e., the railroads, the power systems and communication. This naturally was of tremendous interest. The New England hurricane was the greatest disaster which ever struck this country and the Institute is to be commended for having included a discussion of it in the program.

It was this emphasis on this natural disaster, however, that made the absence of discussion of the Hell Gate disaster more significant. Man it seems is reluctant to direct attention to disasters which are the consequence of his own efforts.

The hurricane session was extremely interesting not only because it demonstrated the fine work of all the public utility agencies in restoring service as quickly as humanly possible but also because it gave those from outside of New England some idea of the tremendous damage caused by that storm. The session opened with a general review of the storm by Walter Weselius of the Red Cross.

Enterprise and Social Progress

Another session of general interest was that on Wednesday morning when Dr. Virgil Jordan delivered an address on Enterprise and Social Progress. Dr. Jordan as president of the National Industrial Conference Board, Inc., is naturally well qualified to speak on a subject of this character and his address was quite interesting but as always with subjects of this kind, not entirely convincing. It was the difference between this address and those of technical interest that gave rise to the thoughts expressed in the opening paragraphs of this report. It seemed to us that if we could discuss our social and economic problems with the same conciseness and clarity that we do our technical problems, we would soon be able to solve them. This is no reflection upon our economists or on their methods of approach. Engineers and scientists, when they discuss social problems, have no more success than the economists and sociologists. To begin with there is the confusion regarding the meaning of the words. When an engineer refers to, say, system stability, or some similar technical conception there is little question in engineers' minds as to which is meant. But when an economist, as Dr. Jordan is, refers to social progress, it is not necessarily clear to everybody as to which is meant. Social progress to one person means something different from what another person believes it to be. It was for this reason, no doubt, that Dr. Jordan at the beginning of his address gave his definition of social progress. Social progress as he put it is to develop, relieve and utilize enough of human energies to enable the combination of enough material and physical energy to defend society.

In terms of this conception of social progress Dr. Jordan then discussed the two principles upon which all different societies are based: 1, Enterprise, and 2, Authority. These he said are the two principles of human organization. The first he pointed out did not come into existence until about 100 years ago—before that all societies were founded upon the principle of authority.

Our democracy, he said, was founded upon the enterprise principle, and though there had been some tendency in recent years to introduce more of the "authority" principle, he believed that this had gone about as far as it could go and that from now on there would be a re-assertion of the enterprise principle in this country. He was, he said, a little more optimistic than he had been in recent years.

Communication

The two sessions on "communication" were of interest not only because of the variety of interests of the papers, but particularly because of two papers, one by Dr. J. H. Dellinger of the Bureau of Standards on "The Role of the Ionosphere in Radio Wave Propagation" and the other by F. J. Scudder and John N. Reynolds of Bell Telephone Laboratories on "The Crossbar Dial Telephone Switching System."

The communication art at the present time is broad and complex and its technique involves the whole field

of physics and electricity. While there were a number of other interesting papers on various phases of communication, the two mentioned were of particular interest in that they represented two widely diverse branches of the art, one dealing with the transmission of electric waves through space and the other with facilities for transmitting voice currents across vast and complex metallic networks.

When Marconi electrified the world in 1901 by sending radio signals across the Atlantic he incidentally proved that the upper atmosphere is electrified. Diffraction was insufficient to explain the bending of the electromagnetic waves around the thirty degrees of the earth's curved surface. The waves could not penetrate the earth. So there was only one way they could go the incredible distance and that was by reflection from one or more conducting strata in the atmosphere. This proved to be the case, and today this conducting strata is called the ionosphere because it consists of a region where the molecules of the atmosphere are highly ionized, a condition induced by the radiation from the sun.

The existence of this ionized region has served to explain all the vagaries of long distance radio transmission and Dr. Dellinger's paper was a resumé of all the experimental and theoretical work that had been done in this field during recent years. It constituted an admirable summing up and anybody even casually interested in the subject will find the paper of interest.

The paper on the Crossbar Dial Switching System served to demonstrate the great advance in another branch of the communication field, that of wire telephony. Sixteen years ago, in February, 1923, a paper was read before the Institute by Craft, Morehouse and Charlesworth of the Bell System, which outlined the history and the problems involved in telephone central office switching and described the panel dial central office system which had just been developed. Since that time 456 panel dial offices serving nearly 4½ million subscriber stations have been installed in 26 different cities. During these years many improvements have been made to make the panel system more serviceable to the telephone public, but in addition the Bell engineers continued their search to find new and better means of meeting switching demands. This work has resulted in the adoption of the "crossbar" type of central office switching equipment described in this paper. This crossbar system is an ingenious system making use of a crossbar switch for all major switching operations. It is essentially a relay system employing simple forms of relays and relay type structures, and represents a great advance in the field of telephony.

It was while trying to follow the speaker through the intricacies of this marvelous product of human ingenuity that we thought again of Dr. Virgil Jordan's discussion of our social problems. No matter how complex or how involved our technical problems, our fundamental knowledge of science enables us to overcome most obstacles, but this is not true when we deal with problems involving man's relation to the world he lives in. Complex and highly specialized as the telephone art is, we felt after the presentation of the paper that we knew something about it—at any rate we felt that the work was in good hands and that whatever problems still remained to be solved, they would be solved. But we were left with no such feeling at the conclusion of Dr. Jordan's address. Noted economist that he is, and though his conclusions were colored with some optimism, his address still left us much in the dark.

On the Teaching of Electronics

Among the various activities of these A. I. E. E. conventions the informal conferences on selected subjects have been features of particular interest during recent years. At this meeting there were five such conferences, one on "Sound," one on "Electronics," another on "Network Analysis," a fourth on "the teaching of Communication and Electronics," and finally one on "Definitions."

These conferences are a valuable feature of the convention because no formal papers are presented and the discussions are entirely informal. Since nothing said at these conferences is printed, those attending feel free to discuss the subjects without the restraint that inevitably is imposed by more formal situations.

The conference on the teaching of Communication, Engineering and Electronics was very interesting, since it showed the extent to which interest in electronics has grown. At one time the subject of electronics was merely a branch of the Communication courses, but the field of electronics has grown to such an extent that today electronics occupies a field all its own. Among other things at this conference the question of teaching students something regarding the construction of electron tubes came up for discussion. Some of the college professors seemed to favor this, but Mr. Thompson of R. C. A. was opposed to it on the grounds that a little knowledge is a dangerous thing and that R. C. A. would rather teach a new man the highly specialized art of tube manufacture in accordance with their vast knowledge of the subject, than to have to "unteach" a student the little knowledge of the subject he picked up at school.

One thing was quite definite at this conference and that was the general agreement that the subject of electronics had grown to such an extent that it could be classified as a separate branch of electrical engineering.

General Features of the Meeting

The convention had the usual full social program with a smoker and dinner dance and the Edison Medal Presentation on Wednesday evening. The Edison Medal this year was awarded to Dr. Dugald C. Jackson and at the same time the John Fritz medal was awarded to Dr. Frank B. Jewett of the Bell Telephone Laboratories.

There were a number of interesting inspection visits to various places of general and technical interest, including, of course, one to the New York World's Fair.

The meeting was well attended, in fact the total registration of 1585 was the largest of any winter convention since 1931.

DELRAY EXTENSION

A Product of Engineering Development

LAST DECEMBER a new 75,000-kw. turbo-generator was put into operation at the Delray plant of The Detroit Edison Co., others are in the course of construction. For a third of a century designers of power plants have studied with extreme interest every major engineering development put into operation by this public utility company which, although conservative in its practices, has been a distinct leader in the field, largely because of its sound engineering policies.

Delray has been historic from an engineering standpoint. Practices which were inaugurated here are reflected in the designs of power plants from coast to coast and just why certain changes have been and are now being made, as told by the engineering staff of this company, will be studied by the leading engineers of the country for the use they can make of the information to be initially published in the pages of this magazine.

In presenting these articles, which will be published in serial form extending over the major part of a year, emphasis will be placed upon the engineering reasoning underlying the design of the plant rather than restricting the articles to a recital of physical equipment and performance figures. It will be the aim, therefore, to give account of why things were done as they were and what other promising ideas were also considered and rejected for one reason or another.

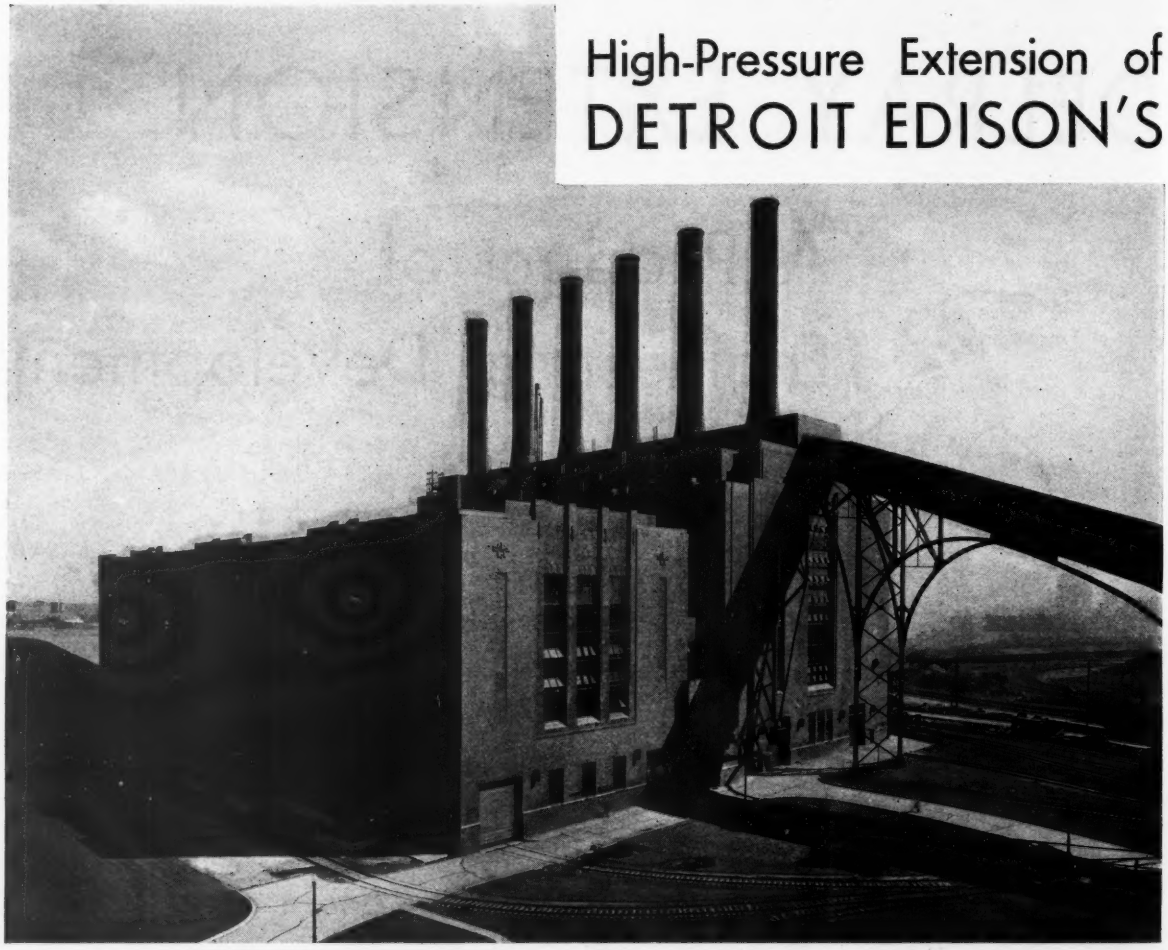
Following the present installment which introduces the serial with a brief historical summary of the power plant developments at Delray and an account of the buildings and prime movers, subsequent installments, which will be published bimonthly, will cover: the coal handling; fuel burning equipment, with a discussion of zone air control and Noblo tuyeres; steam generators, with a discussion on superheat control; the plant operating cycle and heat balance; piping; condensers; auxiliaries; feedwater heaters and an account of operating experiences with the new equipment.

The actual writing of these articles is being done by Max W. Benjamin of the company's Engineering Division, but the technical information and engineering opinions expressed will represent the thinking of the entire engineering staff. All manuscript is reviewed by the engineers ultimately responsible for designs discussed in the articles. The department heads of the engineering staff include: Paul W. Thompson, Chief Engineer of Power Plants, project engineer in charge; William C. Miller, Superintendent of the Electrical System; Arthur S. Douglass, Construction Engineer; and James W. Parker, Vice President and Chief Engineer.

Detroit Edison Co.'s engineers have here an extremely important contribution to make to engineering knowledge and the publishers of POWER PLANT ENGINEERING deem it a privilege as well as a duty to serve the field by publishing this helpful information.

Ralph E. Turner
Editor
POWER PLANT ENGINEERING

High-Pressure Extension of DETROIT EDISON'S



Delray Power House 3

Historical Sketch

IN SEPTEMBER, 1881, the Brush Electric Light Company began to operate series arc-lighting circuits connected to lamps hung outside of stores on lower Woodward Avenue, and in 1883 it contracted with the City for street lighting. The Edison Illuminating Company of Detroit was organized April 15, 1886, having as one of its purposes the operation of the Edison system of direct-current lighting and power in the City of Detroit. In November, 1886, it began serving the Central business area of the city with direct current. The Peninsular Electric Light Company incorporated June 16, 1891, succeeded the Brush Company, and in that year began the supply of alternating current for incandescent lighting. The Peninsular Company was reorganized under the same name on June 17, 1898, and came under the management of The Edison Illuminating Company of Detroit. When The Detroit Edison Company was incorporated in 1903, The Edison Illuminating Company of Detroit and The Peninsular Electric Light Company "owned, directly or by assignment, all the electric distribution franchises outstanding in the City and its vicinity ———." Because the laws of the State of Michigan did not, at that time, "provide for the incorporation of a company with adequate capital, nor for a general electric light and power business being done in Michigan by a corporation of another state," it was planned that The Detroit Edison Company should build, own, and operate, a power plant and deliver its output to "companies qualified under Michigan laws to distribute and market electricity." "The purchase of all the securities of the two Detroit Companies" by The Detroit Edison Company "was according to this plan, and these continued to be our distributing and selling companies in Detroit and vicinity until July 1, 1915, when ———— The Detroit Edison Company undertook to do business directly with its public, without intervention of subsidiary corporations."

Quotations from "Twenty-Five Years," an illustrated history of The Detroit Edison Company from 1903 to 1928.

DELRAY PLANT

By
MAX W. BENJAMIN
Engineering Division,
The Detroit Edison Company

Part I. In this installment, the first of a series of five articles dealing with the most recent engineering and construction work carried out in Delray Plant, the author discusses plant economy, foundation requirements, building structures, machinery locations, and details of the turbines and generators making up the prime movers.

ONE OF THE first undertakings of The Detroit, Edison Company as such after its organization in January, 1903, was the construction of a steam-electric generating station in the village of Delray. In August of 1904, this plant, known as Delray Power House No. 1, began operations with two 3000-kw vertical steam turbo-generators delivering their output as bulk power to distribution companies in the City of Detroit. During the 35 years that have elapsed since that time the increase in number of customers and the growth of their individual demands necessitated the rebuilding of Power House No. 1, the erection of Delray Power House No. 2 and the first section of Power House 3, as well as the construction of power plants at Conners Creek, Marysville, and Trenton Channel, resulting in a total generating capacity of 860,000-kw. Finally, in 1937, it became necessary to return to the scene of the Company's first project where a 225,000-kw extension of Delray Power House No. 3, see frontispiece, is now in process of construction. The last previous major program was the modernization and extension of Conners Creek plant, described in detail in Combustion magazine November 1935 through June 1936. At Delray, old Power Houses No. 1 and No. 2 have long since been shut down and dismantled because of obsolescence. Power House No. 1 buildings have been torn down, while the buildings of Power House No. 2 are being used by the Company's salvage department as a warehouse for storing heavy machinery.

In Delray Power House No. 1, the production of a kilowatt-hour originally required the expenditure of from three and a half to four pounds of coal. The improvement in economy with advances in the power plant art as applied to the growth at Delray is shown in Table I, and, as indicated, the extension of Delray plant operating on the regenerative cycle using throttle steam at 815 psi g 900 F will generate a kilowatt-hour, net, for considerably less than one pound of coal. The engineering principles underlying this remarkable improvement in efficiency are quite well known and will be discussed here only to the extent needed for the purpose of this account which is to indicate how these principles have been applied in the extension of the plant.

Wherever this account compares the extension with the first section of Delray 3 it should be borne in mind that while the extension represents the company's latest practice, the first section still is a modern plant. Technical advances that have been made since the beginnings of Delray 3 are indicated, but there is not the opportunity for spectacular contrasts such as can be pointed out in the case of modernizing an obsolete station.

The earlier Delray plants were built either upon spread footings or upon foundations of the floating-mat type, both resting upon clay subsoil. While these foundations carried their loads reasonably well, there was a considerable amount of settlement in some sections of the plant, which led to the conclusion that the mat-type foundation on Delray subsoil would not be suitable to carry the heavier loadings to be imposed by Delray Power House 3. It appeared necessary to extend the foundation work to bed rock for

TABLE I—STEAM CONDITIONS AND FUEL ECONOMIES OF DELRAY POWER HOUSES

	Steam Conditions		Coal Rate
Delray PH 1	Psi g	F	Lb. per kw-hr.
1904-1906	190	550	3.51
1907	"	"	3.21
Delray PH 2			
1909	"	"	2.40
PH 2 and PH 1 rebuilt			
1912	"	"	2.20
1918	"	"	1.92
Delray PH 3			
1929	375	700	1.195
1933	"	"	1.078
1937	"	"	1.037
Delray PH 3 Extension			
1938	815	900	less than 0.9

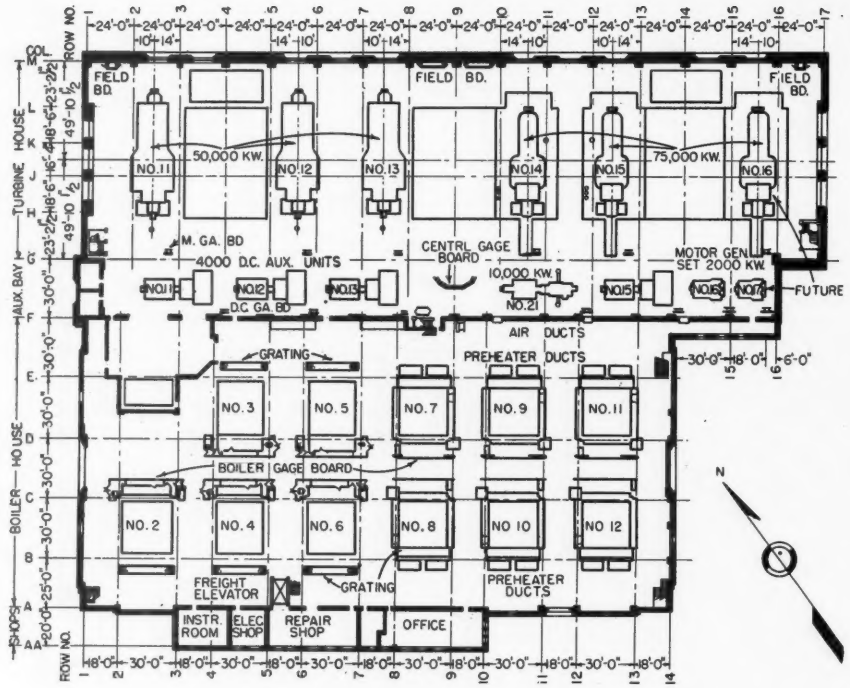


Fig. 1. Operating floor plan of the ultimate plant

the new plant, and the development of a caisson-type foundation was undertaken.

Rock formation at Delray lies about one hundred feet below grade and carries veins of sulphuretted water, while above the rock is first a stratum of hard pan and above this a soft, mobile, blue clay which drifts into any excavation. The method ultimately adopted was to drill holes to hardpan, using a four and one-half foot diameter, engine-driven, water-lubricated auger. The mud formed by mixing the loosened earth with the lubricating water was left in place to exert hydraulic pressure against the surrounding earth and thus prevent the drift of soil into the hole.

When hardpan was reached a vertical steel cylinder was sunk through the mud and driven far enough into the hardpan to anchor the cylinder and provide a seal against the influx of water. The mud core inside the cylinder then was excavated with a bailer and orange-peel bucket. Hardpan at the bottom of the cylinder was excavated by hand digging. In many cases it happened there were fissures in the bed rock through which sulphur-charged water entered the caisson. It was necessary to seal the fissures to permit pouring the concrete and to protect the freshly poured material from the possibly harmful effects of the sulphur water. The treatment here was to force liquid cement-grout at high pressure into the fissures through six-inch pipe wells driven into the rock adjacent to the caisson. The dry hole then was filled to grade with concrete. This method of construction is now used quite extensively for deep foundations in the Detroit area and has proven entirely satisfactory for such work. Caissons for the extension of Delray were sunk and foundations poured in 1931 when construction men were available and in need of useful work.

Delray Plant

Building Structures

THE FIRST section of the present Delray plant consists of a boiler house containing five boilers and one vacant boiler bay, an auxiliary bay which houses three direct-current geared turbo-generators, and a turbine room housing three 50,000-kw turbo-generators operating on throttle-steam conditions of 375 psi g 700 F. The vacant boiler bay housed for some time an oil-fired 1000 F superheater used in connection with a 10,000-kw experimental high-temperature turbo-generator. The separately fired superheater used in that experiment has been dismantled, and the 1000 F turbo-generator is being rebuilt for topping service as a link between the old and new sections of the plant.

As a second step in the plant construction, the buildings have been extended to house six additional boilers, three more d-c auxiliary machines, and three 75,000-kw main turbo-generators. A seventh boiler probably will be installed in the boiler position made available in the first section by removal of the oil-fired superheater. The operating floor plan of the completed plant is shown in Fig. 1. Transverse views of the first section of the plant and of the extension are shown in Figs. 3 and 4.

Boiler House

The boiler house was originally laid out to accommodate two rows of fairly high capacity boilers,

the building columns being arranged on centers 30 ft by 30 ft in the boiler area with all transverse aisles 18 ft wide and with longitudinal aisles 30 ft wide between the two rows of boilers and between the boilers and turbine-room wall. The longitudinal aisle between the boilers and outer building wall is 25 ft wide. Since boilers of adequate capacity to serve the new turbine units could be installed within the original column spacing, the steel for the new boiler house was extended with identical centering. Although the new boilers are taller than the old ones by some 5 ft to the center-line of the uppermost drum, it was possible by careful planning and arrangement to continue the fan-room floor, main roof, and coal handling equipment in the upper regions of the boiler house at the same elevations as in the first section of the plant.

Three self-supporting steel stacks identical with those of the first section of the plant have been erected on the extension. These stacks, which are 13 ft 6 in inside diameter, extend 127½ ft above the boiler house roof and terminate at an elevation 270 ft above grade.

The boiler-room operating floor and the boiler structure itself are at elevations which permit dumping the furnace refuse directly into railroad cars that are run in underneath the clinker-grinder pit. The space below the central operating aisle provides ample room for accommodating certain miscellaneous equipment, including a boiler-tube-bending machine used to bend replacement tubes for boilers of all the power plants and central heating plants of the Company.

In overall dimensions the boiler house is 306 ft long, 145 ft wide and 142½ ft high.

Turbine House and Auxiliary Bay

The turbine house of the completed plant is a structure approximately 384 ft long, 100 ft wide, and 106 ft high. Interposed between the turbine room and boiler room is an auxiliary bay, essentially a part of the turbine house, 30 ft wide, 63 ft high, and 360 ft long.

The main-turbine room, which was laid out originally for six 50,000-kw turbo-generators, is of ample proportions to accommodate three 75,000-kw units in the extension in addition to the three 50,000-kw machines already installed in the first section. Actually, as may be noted in Fig. 1, the floor space required for one of the 75,000-kw units is somewhat less than that for one of the 50,000-kw machines. This results from the increased density of the throttle steam, the increase of rotational speed from 1200 rpm to 1800 rpm, and the use of only 17 stages in the new turbine in place of 21 stages in the older machines.

The turbine room proper is entirely free from auxiliary equipment of any kind. There are no boiler-feed pumps, motor-generators, vacuum pumps, heaters, or any other operating appurtenances on that part of the floor between crane columns in the main-turbine room.

Crane facilities in the main-turbine room extension were provided merely by extending the rails and trolley for the existing 125 ton crane, which is adequate to handle any part of the new turbo-generators.

The auxiliary bay houses the direct-current generators, three of which are turbine-driven geared units installed with the first section of the plant. The extension of the auxiliary bay will contain two 2,000-kw motor-generator sets and one turbine-driven geared set of 4,000-kw capacity operating on 815 lb 900 F steam. A 10,000-kw superposed unit using the generator and some of the turbine parts from the experimental high-pressure machine previously referred to also will be installed in the auxiliary bay between the old and new sections. A crane of 35 tons capacity serves equipment located in this bay.

Boiler-feed pumps, main condensers and their auxiliaries, generator-air coolers, and miscellaneous pumps, are located in the basement of the turbine house. Feedwater heaters, evaporators, and auxiliary condensers are located on a mezzanine below the auxiliary bay between the turbine room basement and operating floors.

Screen House and Canals

When the first section of Delray Power House 3 was built, the forebay of the old intake canal was improved with the idea that it would be adequate for the ultimate Delray plant. On the west side of the forebay a half of the ultimate screen house was built

Fig. 2. Waterman station, which controls Delray output

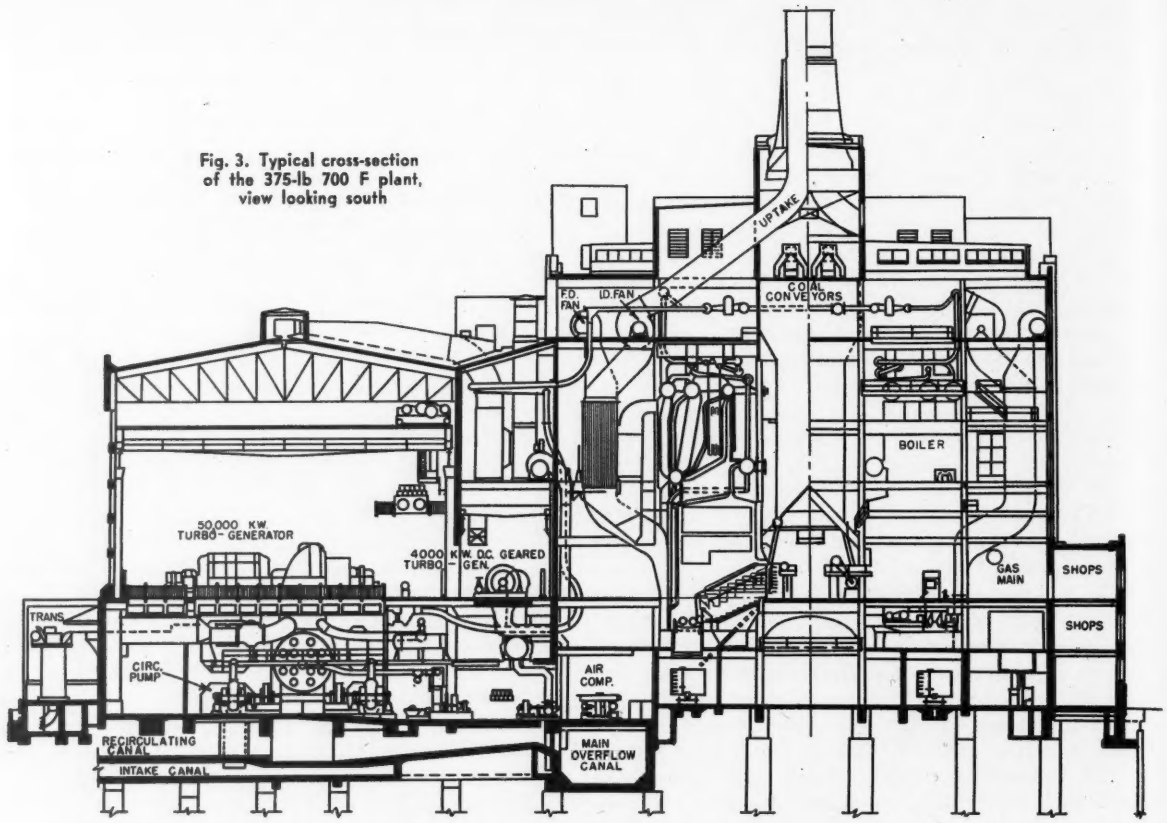


Fig. 3. Typical cross-section of the 375-lb 700 F plant, view looking south

and equipped with screens to serve three main units, while two intake tunnels, each adequate for two main turbo-generators, were constructed between the screen house and power plant. With the advent of the new 75,000-kw machine the screen house was completed and additional screens installed to serve the new unit. When the second 75,000-kw machine is installed, it will be necessary to build a third intake tunnel to the power plant, and for the ultimate plant it may be necessary to install more screens.

The Power House 3 overflow canal was built for the future, looking to an ultimate capacity of 600-000-kw on the Delray site. It was so arranged that the overflow from the older Delray plants discharged into it, and is designed for a future connection from a large plant to the north of Power House 3.

The margin of canal capacity for future growth at Delray has been increased as a result of progress in the power plant art. Due to the increased throttle pressure and temperature and to the relatively greater amount of steam bled, the condenser steam flow of the 75,000-kw unit is only 6.18 lb. per kwhr, while the older 50,000-kw machines have a condenser steam flow of 8.11 lb per kwhr. Chlorination of the condenser-cooling water also increases the canal capacity margin, since it maintains the tubes in a clean condition, thereby permitting a marked reduction in the amount of cooling water used as compared with regular practice when Delray Power House 3 was first designed.

Switching, and the regulation of load and voltage of the generators in the Delray plant are controlled in the Waterman Station, shown in Fig. 2, some 2000 ft north from the power house. Waterman Station was built originally in 1920 to handle the output of Power House 2 which, until then, had delivered its output directly to large industrial customers as well as to various substations. In 1928 the station was modernized and enlarged to accommodate the first three 50,000-kw units in Power House 3. After the third of these units was installed, Power House 2 was shut down. The present switching station is adequate for the three 50,000's, for the 10,000-kw superposed unit, and for two 75,000's. An extension of the switching station will be necessary when the third 75,000-kw unit goes in.

Experience with the modernized Waterman Station weighed heavily in the design of Essex Station described briefly in the Conners Creek modernization article previously referred to, and more extensively in "Electrical Engineering" for January, 1934. An account of the Waterman Station appears in "Electrical World" for May 24, 1930. Features of the design and construction of Waterman, summarized from the "Electrical World" article, are as follows:

(1) The basic principle of design is the complete inclosure of each phase conductor in a grounded metal housing so that line-to-ground is the only fault possible. This has been accomplished in all cases except at bus potential transformers, which are protected by fuses and resistors mounted in separate phase compartments, and cable potheads that are mounted in metal housings grounded separately from the bus and switch housings.

Fault protection is provided by current transformers in the ground connections which actuate relays to trip breakers in the faulted section of the station bus.

(2) Possible damage from explosions and oil fires is minimized by the use of live pot H-breakers, metal-inclosed air-cooled reactors, air-insulated buses, and the division of the building into separate switch rooms by means of barrier walls.

(3) The H-breakers are mounted in individual cells which are connected to a ground-network. Every reasonable effort is made to confine fault currents to definite predetermined paths to ground and to keep them away from reinforcing rods, conduit, and building steel.

(4) Doors of disconnecting and oil-switch compartments are interlocked with their corresponding circuit breakers in such a way that it is impossible to open a switch compartment until after the breaker has been opened.

Since the 1928 modernization of Waterman Station two rooms have been added to accommodate bus and switches for tie lines from other major switching stations. One of these, Navarre, handles part of the power generated at Trenton Channel and the other, Essex, handles the entire output of the Conners Creek plant. Additional reactors were installed at Waterman as a means of limiting short circuit values which would otherwise have been imposed by the new high-capacity generators at Delray.

Figure 5 is a diagram of The Detroit Edison Company electrical system showing the relationship of Delray plant and Waterman Station to the system.

Buildings Summary

All major dimensions of the building extension duplicate the corresponding items in the first section of the plant. Column centers and elevations have all been kept the same as in the original building. As a result, the completed building structure presents a unified architectural appearance inside and out. After a good exterior cleaning the brickwork of the first section matches perfectly the new part of the building. The frontispiece shows the completed plant, looking southwest toward the turbine house.

Delray Plant

Prime Movers

THE SELECTION of prime movers for the Delray extension involved two major problems, namely, what size units should be used and what initial steam conditions should be selected. Each of these problems consists of several factors.

Size of Unit

The principal considerations involved in deciding upon the size of the unit are

(1) the capacity of the electrical system (measured in kw)

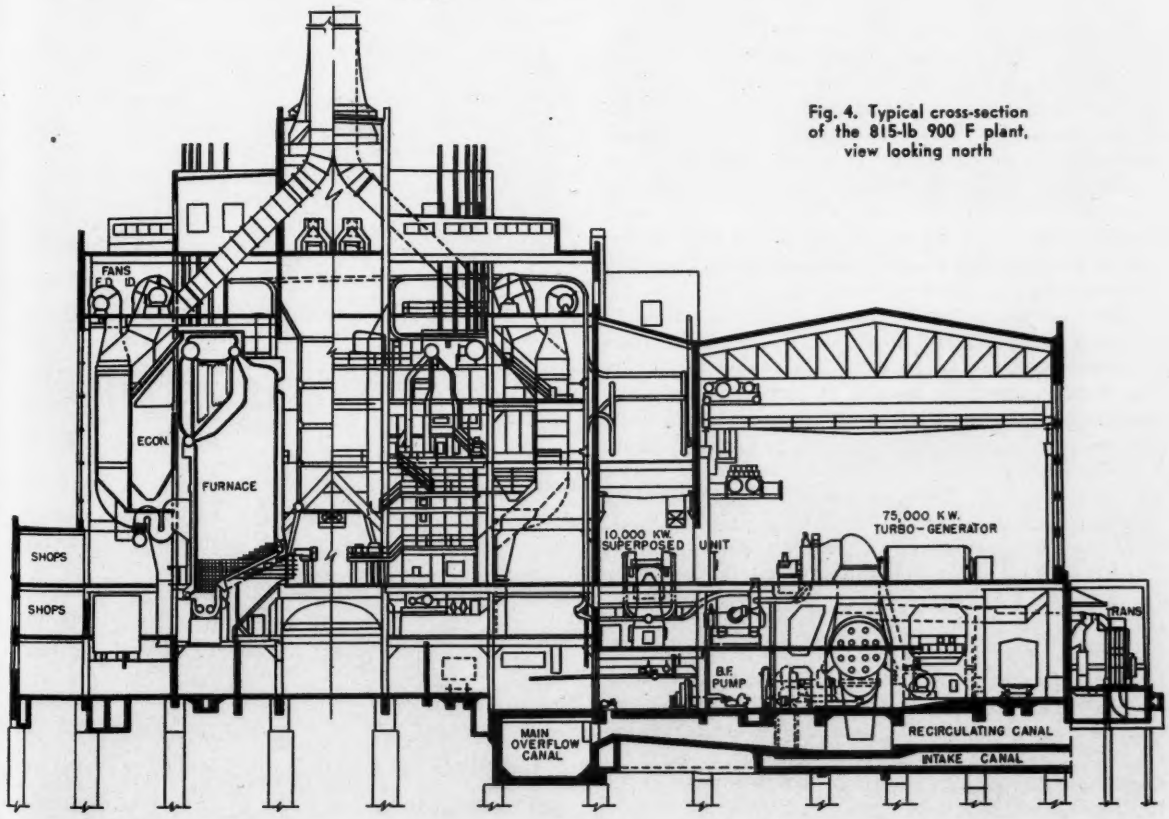


Fig. 4. Typical cross-section of the 815-lb 900 F plant, view looking north

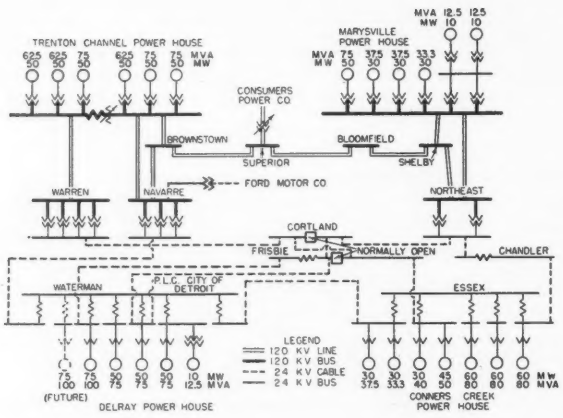


Fig. 5. Diagram of Detroit Edison electrical system

(2) the expected rate of load growth of the system and of the area served by Delray Plant

(3) the effect on "firm capacity" of both plant and system

(4) the effect of size on cost per kilowatt of capacity.

Some of these factors favor a large unit while others weigh in the direction of a smaller size. It is obvious that some particular relationship between the size of the generating unit and the capacity of the system it serves will produce the optimum result from the standpoint of investment as well as operating economy. For example, an over-large unit might have to be kept in operation at poor economy during light-load periods because of the expense involved in frequent starting and stopping, or because its continued operation was required to maintain adequate running reserve. From the investment standpoint too large a unit is undesirable since it necessitates the installation of a relatively larger amount of reserve capacity in additional machines to cover its outage, if system reliability is to be assured. This will be covered more completely under the comments on "firm capacity." The unit, therefore, should be of proper size to fit well in the loading schedule and to minimize the required amount of reserve capacity.

From a construction viewpoint it often is advisable to install units of a size about one and one-half times the annual system-load growth. The reason for this is that it takes about 18 months to carry out the work necessary to the installation of a large modern unit, and because of construction personnel requirements it is desirable to have only one major project under way at a time. If, however, a slow rate of growth is expected in the area to be served by a proposed unit, there may be justification for selecting a somewhat smaller machine than would be needed in the faster growing areas of the system. The Detroit Edison system is quite flexible, however, and tie lines between the several plants are heavy enough to permit the installation of new units in the fastest-growing area while the growth in other areas is carried by the system as a whole until such time as operating convenience and system reliability dictate an increase in generating capacity in the slower areas to relieve the tie lines.

The Detroit Edison Company's practice with reference to firm capacity and continuity of service may be stated as follows: The firm capacity of an individual plant is equal to the sum of the ratings of all main generators in that plant plus the available aid from other sources (that is, tie lines), minus the rated output of the two largest units in the plant, modified if necessary by boiler capacity. This definition recognizes the need for routine repair of each main unit in turn together with the fact that there may be an emergency outage of another machine while the first unit it still under repair. Although periodic overhauling is scheduled for the light-load season of the year whenever possible, nevertheless the coincidence of a heavy industrial load and a daytime lighting load due to thunder storms is apt, at any time of year, to produce a short-time load equal to the seasonal peak. This concept of the firm rating of an individual plant (or its corresponding load area) is of special interest in the design of the electrical system and in the operation of an individual plant, and it is fundamental to the construction and use of properly proportioned ties between the various plants or load areas.

The firm capacity of the system as a whole is quite another matter and is of chief interest to the staff responsible for the operation of the entire system. System firm capacity is not merely the summation of the firm ratings of all the plants in the system as just defined. It is assumed, rather, to be the sum of the ratings of all main generators in the system, plus the available aid from outside sources, less the capacity of three machines which are not necessarily the largest in the system. These three machines will have, however, an aggregate capacity appreciably greater than that of the two largest. The capacity at any plant must if necessary be modified by the boiler capacity there available. For instance, at the present time, with its 23 main turbine units aggregating 945,000-kw nameplate rating, together with 50,000 kw from interconnections, the Detroit Edison system is assumed to have a firm capacity of 840,000 kw. The available capacity is made up as follows:

Plant	Number and Size of Machines		Total Capacity, kw
Delray	1—	75,000	75,000
	3—	50,000	150,000
	1—	10,000	10,000
Conners Creek	2—	60,000	120,000
	1—	40,000	40,000
	3—	30,000	90,000
Marysville	1—	50,000	50,000
	3—	30,000	90,000
	2—	10,000	20,000
Trenton Channel	6—	50,000	300,000
Total in generating plants			945,000
Interconnections			50,000
Total available			995,000

Turbo-generator Unit 14

During Installation at Delray

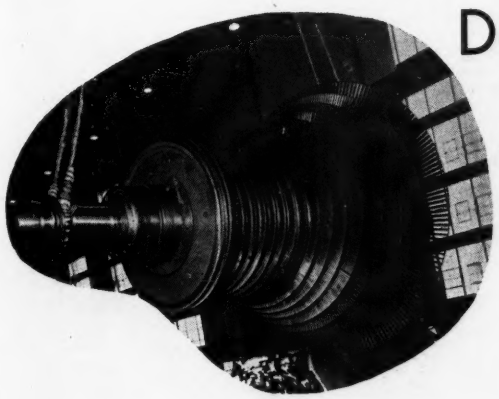


Fig. 6. Rotor of 75,000-kw turbine, Unit 14

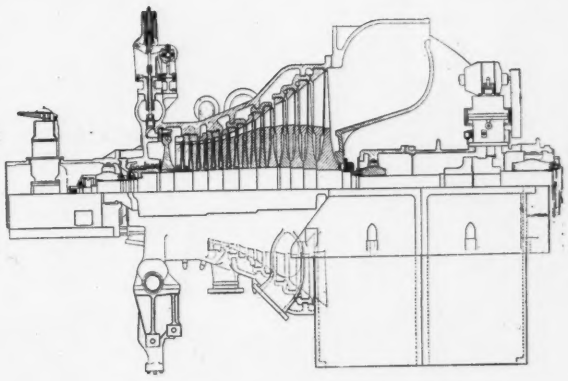


Fig. 7. Longitudinal semi-section of 75,000-kw turbine

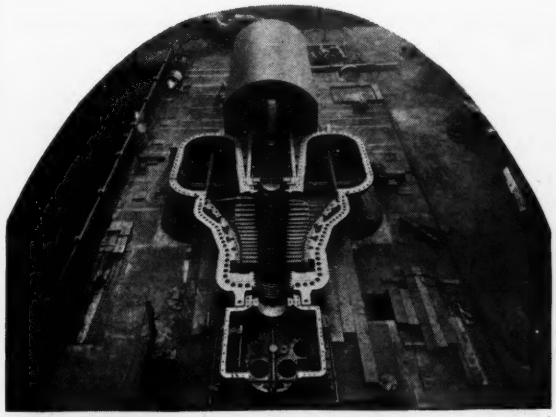


Fig. 8. Lower half of Unit 14 turbine casing with lower halves of interstage diaphragms in place

Fig. 9. End view of 75,000-kw generator armature

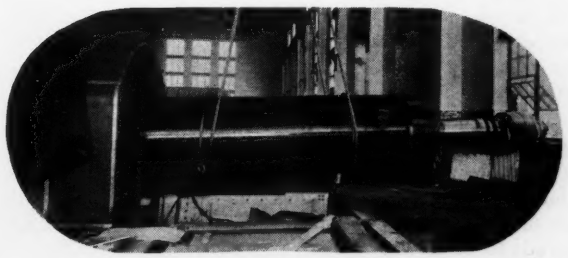
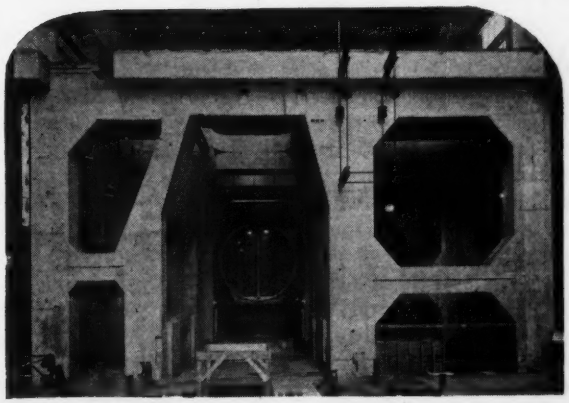


Fig. 10. 75,000-kw field being moved into position within the armature. Note the overhung exciter armature

Fig. 11. Turbine base for 75,000-kw Unit 15, identical with that for Unit 14. Unit 14 condenser in background



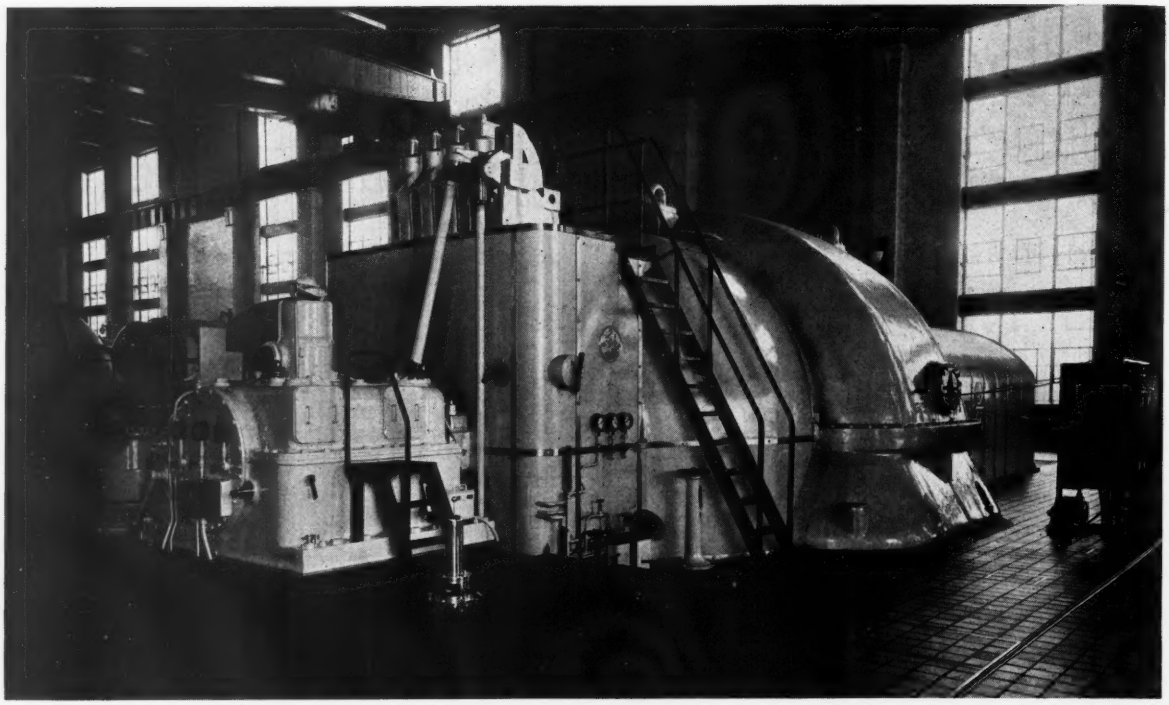


Fig. 12. View of completed 75,000-kw turbo-generator Unit 14. The instrument on the extreme right is an absolute pressure gage used in special test work

Earlier in the growth of the system it was sufficient to assume only two units down in reckoning firm capacity, but there are now so many machines involved that it may be necessary at times to have two units under scheduled repair simultaneously while a third machine may require emergency shutdown. At the present stage of system development it will not be necessary to schedule two of the largest machines for repairs at the same time, and every effort is made to plan their overhauls for periods when only one unit needs to be down.

From these definitions it follows that the installation of larger machines than those previously used does not increase the firm capacity of an individual plant beyond that which would be obtained by continuing with the previous size, until three of the larger units have been installed. In the meantime, the larger size involves greater fixed charges per kilowatt of firm capacity, thus influencing the decision in the direction of smaller units.

In addition to the three factors discussed above, there is at least one more that enters the problem of turbine size. In general, the larger the turbine the lower will be its cost per kilowatt of rated capacity. An exception to this rule occurs at the capacity at which it becomes necessary to change from single casing to multi-casing design. At that point there is an abrupt increase in unit price followed by decreasing unit cost as the size is increased still further.

A unit of 75,000 kw capacity finally was chosen for the Delray extension as representing the best compromise of all these factors.

In the first section of Delray Plant, steam conditions of 375 psi g and 700 F at the turbine throttle were selected on the basis of the limitations of riveted boiler-drum construction, the Company's partiality for the simple regenerative cycle, and the lack of suitable materials for use in superheaters, piping, and turbines at temperatures much over 700 F.

Experience with the 1000 F experimental unit at Delray, combined with developments in metallurgy and in the design and construction of welded boiler drums, led to the selection of steam conditions of 600 psi g 825 F for the modernization of the Conners Creek plant. Satisfactory performance at Conners Creek eliminated the need for considering steam conditions as low as 375 psi g 700 F for future plants, and confirmed the opinion that the Delray extension should operate at 600 psi g 825 F or higher. Therefore, an analysis was made using initial steam conditions of 600 psi g 825 F, 850 psi g 900 F, and 1200 psi g 950 F, in the regenerative cycle.

Compared with 600 psi g 825 F, the studies showed a thermal improvement for 850 psi g 900 F sufficient to justify not only the slightly greater cost of the turbines but also the more important increase in cost of boilers, piping, pumps, feedwater heaters, and the like. The case for 1200 psi g 950 F was not so convincing, however. With the loading conditions that can be expected for Delray over a period of several years, the thermal gain between steam conditions of 850 psi g 900 F and 1200 psi g 950 F was not great enough to pay for the additional investment required. It should be borne in mind that these comparisons were made for straight regenerative cycles without reheat.

The old section of the plant is modern enough to seriously limit the gain that could be made through

superposition, irrespective of the initial steam conditions in the plant extension. Some superposing will be done, as described later on, but this is merely incidental and could not be given much weight in choosing throttle-steam conditions for the new condensing machines.

Consideration of manufacturers' proposals for boilers and turbines made in the light of these thermal studies lead finally to the choice of 815 psi g at 900 F for normal throttle conditions although the turbine is designed to withstand steam at 850 psi g 910 F as an occasional maximum for periods not exceeding 15 minutes' duration.

Delray Plant

Construction of New Turbines

THE NEW TURBINES rated 75,000-kw at 1800 rpm are single-cylinder machines having 17 pressure stages, the first of which is a two-row compounded-velocity stage. The 18 rows of revolving buckets can be seen in the photograph of the turbine rotor shown in Fig. 6. The high-pressure turbine casing is of carbon-molybdenum steel, split horizontally, each half having cast integrally with it the corresponding half of the valve chest and first-stage nozzle-chest. The upper and lower halves are almost perfectly symmetrical. Three inner shells are used to group the diaphragms from stages 8 to 16, thereby helping to shorten the span between bearings to approximately 14 ft. 3 in. The exhaust hood of cast iron is bolted to the high-pressure casing practically in the plane of the exhaust wheel.

The turbine wheels are shrunk upon a forged carbon-steel shaft and keyed in position. The first and second wheels are forgings of nickel-chrome-molybdenum steel, third to ninth are of carbon steel, tenth and eleventh are nickel steel, while the twelfth to seventeenth are again nickel-chrome-molybdenum steel. All buckets are of corrosion-resisting material, in addition to which the last-stage buckets are fitted with stellite protecting strips.

Diaphragms for the first eight stages are of a welded type, while cast-in type construction is used for the remaining stages. Second and third-stage diaphragms are of carbon-molybdenum plate; fourth to eighth are carbon-steel plate; ninth to thirteenth are cast steel; and fourteenth to seventeenth are cast iron. Nozzle partitions of chrome-iron alloy are used throughout.

A comparatively flat economy curve over a wide range of loads is obtained by the partial-admission governing system employing eight governor-controlled valves, all of which admit steam to the first stage nozzles. Four control valves are located in the upper half of the turbine casing and four in the lower half, opening in a sequence alternating between upper and lower steam chests to effect uniform heating of the two casing halves. The valves and seats are of nickel-chrome-molybdenum steel with stems and bushings of Nitralloy. There are no by-pass overload valves.

The turbine is equipped with a quick-closing, oil-operated stop valve having a removable internal steam strainer. This valve may be tripped closed either by hand or by an automatic oil-trip emergency overspeed governor.

A turning engine, mounted on the middle bearing of each new unit and geared to the turbine shaft through an automatic release, revolves the turbine rotor at about 1½ rpm during the cooling period following shutdown of the machine. As a result of slow rotation the turbine rotor cools uniformly around the circumference, so that bowing of the shaft which would occur if the rotor cooled in a stationary position is eliminated. Because the shaft cools without bowing, the machine is in good condition for quick starting when needed and at the same time overall turbine efficiency is improved because it is possible to set and maintain smaller clearances on the high-pressure and inter-stage packings without rubbing. The older turbines at Delray originally were installed without turning engines, although these devices have been added in recent years and new close-fitting diaphragm packings have been installed.

The high-pressure shaft packing is of the spring-backed combined labyrinth and water-seal type. The steam-packing sleeve is of nickel-chrome-molybdenum steel, the steam-packing rings are of leaded bronze, while the water-packing runner and casing are of chrome-iron alloy. The low-pressure shaft packing is a straight water-seal type, having a bronze runner and cast-steel casing with a chrome-iron liner. Diaphragm-packing rings are spring backed. Machine steel is used in the higher-pressure stages, but the lower-pressure stages have bronze inserts. The corresponding shaft sleeves of labyrinth type are of nickel-chrome-molybdenum steel and chrome-iron alloy, respectively.

The turbine is solid-coupled to the generator.

The cross-section drawing reproduced in Fig. 7 shows the arrangement of casing, inner shells, diaphragms, rotor, and exhaust hood. Figure 8 is a photograph taken during erection of the first 75,000-kw unit showing the lower half of the turbine casing with the lower-half diaphragms in place. Figures 7 and 8 both show extraction passages inside the turbine casing for the four stages of regenerative feedwater heating. These passages are designed for bleeding from the fourth, seventh, tenth, and thirteenth stages. Further detail of the extraction cycle will be found in a later section devoted to "Plant Heat Balance."

Generator

The generator rotor is a three-piece nickel-steel forging having slots milled out for the field coils. The turns of the field coils are insulated with continuous mica tape and are protected in the slots by molded mica and asbestos armor. The end turns are protected with aluminum coverings to prevent rubbing between insulation and retaining ring during expansion and contraction of the coils, and to conduct heat away from the end turn assembly.

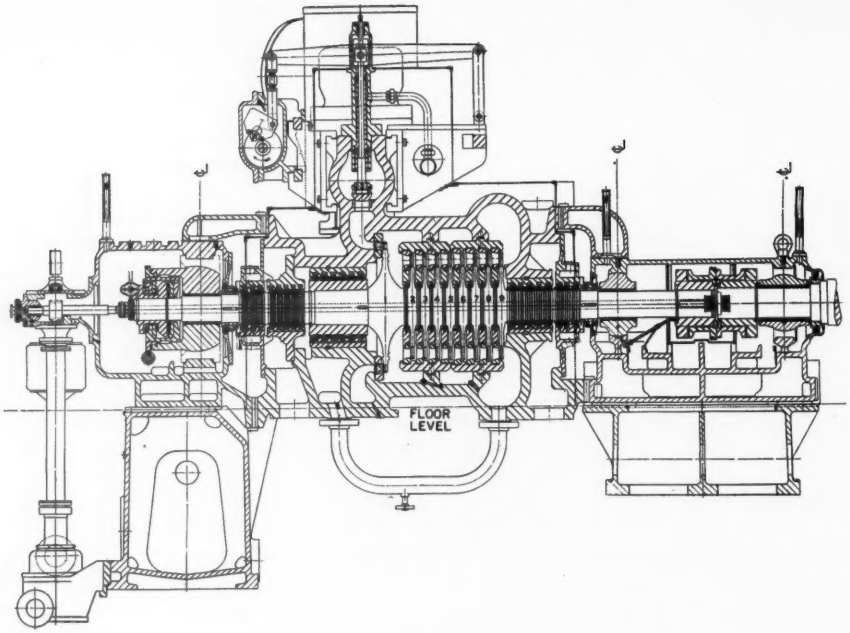


Fig. 13. Cross-section view of 10,000-kw. superposed turbine

The generator stator is of the inclosed type, having a built-up frame of welded steel plate. A transposed bar type of winding is used with two conductors per slot. Circulating current losses in the conductors are reduced to a minimum by complete transposition of the individual strands. Each bar is insulated with mica tape and covered with asbestos tape to form slot armor. Heat losses due to induction in the ends of the machine are minimized by the use of non-magnetic material for the armature binding bands, supporting brackets, flanges, and clamping fingers. An end view of the stator showing some of these features is presented in Fig. 9. The stator, which was completely assembled and wound at the factory, was shipped and installed as a single piece weighing just over a quarter million pounds.

A 250-kw stabilized, shunt-wound, direct-current exciter is driven from the end of the main-generator shaft. The exciter is entirely inclosed and obtains its ventilation from the main ventilating system. While this detail is new at Delray, it is similar to the design used in the 60,000-kw machines at Conners Creek. The overhung exciter armature may be seen in Fig. 10 showing the generator field being moved into place.

Ventilation is provided by four external, motor-driven, centrifugal fans circulating up to 130,000 cfm of air through the generator and exciter, and over a surface-type air cooler. Three motors are direct connected to the generator through an auxiliary transformer; the fourth is supplied from the house service bus for use during starting periods and for periods of high load and high circulating water temperature. The motors are designed for individual full voltage starting at 230 v. The separate controls allow a power saving of 75 hp in periods of low water temperature and at fractional generator loads. Carbon dust from the collector-ring brushes and exciter brushes is removed from the ventilation air by renewable filters. The generator is rated 100,000 kva at 0.75 pf, 1800 rpm, 14,400 v. The short circuit ratio is 1.0. It will carry full rated kva at 0.75 pf at voltages within plus or minus five per cent of the rated voltage without exceeding permissible temperature limits of the armature and field.

The turbo-generator is mounted independently on its own reinforced concrete foundation, no support being derived from the building floor or steel work. Figure 11 shows the foundation for the second 75,000 shortly after the forms were stripped off. Figure 12 shows the completed turbo-generator unit with the older 50,000-kw machines in the background.

Delray Plant

10,000-Kw. Superposed Turbine

AS PREVIOUSLY mentioned, the 10,000-kw high-temperature experimental turbine has been rebuilt for superposing service in the final plant. This turbine operates on steam at 815 psi g 900 F and exhausts at 410 psi g into the main steam header of the low-pressure section. Temperature of the exhaust steam will vary from 740 F at full load to 780 F at 2,000-kw. The advantages of the arrangement are that a considerable amount of by-product power is generated at low heat rate, the generator and some of the turbine parts from the now completed high-temperature experiment are put to use, and upwards of 500,000 lb per hr of steam from the high-pressure section are transferred to the low-pressure section which is otherwise hard pressed for steam at heavy loads.

In its reconstructed form, the 10,000-kw machine is a single-casing, 3600 rpm, eight-valve, nine pressure stage unit built around the shaft and integrally forged wheels of the high-pressure rotor of the original machine. In addition to the shafts and wheels, the following parts of the original unit have been reused. Existing stop valve (in parallel with a new stop valve), governor, main and auxiliary oil pumps, cam gear, oil tank base under governor-end pedestal, center pedestal and pedestal support between the original h-p and l-p cylinders, and coupling between alternator and original l-p shaft. The turbine casing, diaphragms, wheel buckets, steam chest, control valves and other parts not already mentioned are new.

The governing arrangement is, perhaps, the most interesting feature of the superposed turbine. Hydraulically operated devices are installed to perform under the following conditions:

(1) Primarily a centrifugal speed governor and relay regulate the steam flow.

(2) With abnormally high back pressure, an over-pressure regulator readjusts admission valve openings to reduce the steam flow as necessary to an adjustable predetermined limit.

(3) If the back pressure reaches a pre-set high limit irrespective of the operation of the over-pressure regulator, an emergency over-pressure governor operates to close simultaneously both stop valves and all control valves. In addition to the over-pressure governor, safety valves relieving to atmosphere are installed as last resort protection for the turbine and piping.

(4) Per contra, with abnormally low back pressure, an under-pressure regulator again readjusts the admission valves to increase the steam flow. The under-pressure regulator is adjustable to maintain any desired value of subnormal back pressure. If, in spite of this readjustment, the back pressure continues to fall, a differential-pressure control overrides the under-pressure regulator to restrict the steam flow to a value which will avoid too great a pressure differential across certain lower-stage diaphragms. This will also act to prevent excessive generator loading.

(5) Should the machine lose its load when the under-pressure regulator is functioning, the speed governor will normally take over control as soon as the speed commences to rise, thus preventing overspeed. Note again that none of the back-pressure actuated devices actually supersedes the speed governor should the generator become separated from the system or in any other way drop its load.

(6) Failure of oil pressure causes the main stop valves to close.

(7) In the event of overspeed, an emergency speed governor of conventional type operates to close simultaneously both stop valves and all eight control valves. This governor also may be operated by a manual trip.

Besides the various governing devices installed on the superposed unit, it is believed essential to provide some additional protective apparatus to safeguard its operation and that of the low-pressure section of the plant to which it exhausts.

The first of these extra safety devices is a reverse-current relay which will operate the machine breakers to disconnect the generator from the bus in order to prevent "motorizing" the generator in case the turbine trips out for any reason, such as, overspeed, or failure of oil pressure. The necessity for this reverse-current protection arises from the fact that the windage loss of the turbine running at full speed in a steam atmosphere at 400 psi g pressure will amount to an estimated 1,170 kw.* It should be understood that the windage loss is nowhere near this figure when the machine is carrying load, but if its steam supply were cut off and the turbine were driven at full speed by the generator acting as a motor, this estimated loss would obtain. Considering only the amount of steam contained within the clearance spaces of the turbine, the 1,170 kw windage loss would cause a rise of temperature at the rate of from 100 to 200 degrees F per second. In addition to the steam contained within the turbine, however, there is a large mass of metal which also will be heated due to windage, and this has the very beneficial effect of reducing the rate of temperature increase to about 65 F per minute. It is obvious, however, that the unit must not be allowed to "motor" very long.

The reverse-current relay will be installed to operate on a time delay of 60 sec. and will be as rugged a device as possible. It is believed that no ill effects will result from a turbine trip-out with this relay operating. Neither is any dangerous temperature to be expected in bringing the turbine to rest in the normal manner, without load.

Automatic Governor Control

Another device necessitated by the installation and use of the superposed turbine is a pressure-operated control arranged on each 50,000-kw 400-pound unit to unload the machine in case of a sudden loss of load on the superposed turbine. The need for such a device comes about as follows:

Operation of the superposed machine in conjunction with the 400-pound condensing units contemplates, under conditions of light plant load, supplying the low-pressure section with steam taken largely from the superposed unit. One or two low-pressure boilers would be carried on a "floating bank," that is, at the lightest rating consistent with maintaining full pres-

*See "Windage Resistance of Steam-Turbine Wheels" by Edgar Buckingham, Reprint No. 208 from Bulletin of The Bureau of Standards, Vol. 10.

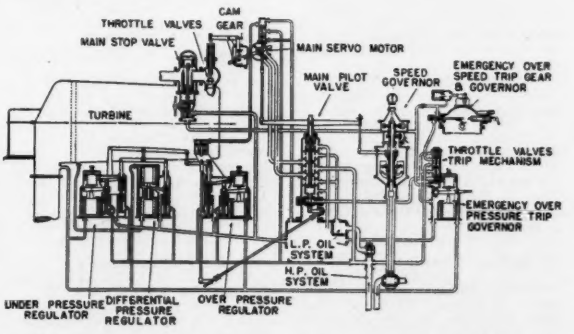


Fig. 14. Diagram of governing arrangement for 10,000-kw. superposed turbine

Principal Equipment at the Delray Plant

815 Lb 900 F Extension

Main Turbines
75,000-kw, 815 psi g, 900 F, 1800 rpm; 1 two-row Curtis and 16 single-row stages; bled at 4th, 7th, 10th and 13th stages.
General Electric Co.

Main Generators
100,000 kva, 0.75 power factor, 14,400 v, 4 pole, 60 cycle, 3 phase.
General Electric Co.

Main Condensers
53,620 sq ft, single pass, 11,504 tubes 24 ft 0 in long, ¾ in OD 18 gage.
Worthington Pump & Mach. Corp.

Main Circulators
One per condenser, 48-in horizontal double-suction volute pump, 67,000 gpm at 17.1 ft head, 250 rpm. General Electric 240 v, d-c motor, 150 to 400 hp 175 to 250 rpm.
Worthington Pump & Mach. Corp.

Main Unit Vacuum Pumps
Three-element, three-stages per element, steam air ejector, with three-stage inter and after condenser, steam consumption 285 lb per element, using 190 psi g saturated steam.
Single stage priming ejector exhausts to atmosphere, 21 lb air per minute at 15 in hg abs, steam consumption 2300 lb per hr.
Worthington Pump & Mach. Corp.

Oil Coolers
Duplicate, vertical type.
Schutte & Koerting Co.

Oil Filtration
Portable Separator for main units, 300 gph. Individual separator for auxiliary units, 300 gph.
DeLaval Separator Co.

Batch Oil Filter
Wm. W. Nugent & Co.

Generator Air Cooler
One per main unit, 19,400 sq ft cooling surface, 130,000 cfm.
General Electric Co.

Generator Ventilating Fans
Four external fans per main unit, each driven by direct connected induction motor operating at 220 v, 100 hp, 1175 rpm.
General Electric Co.

Superposed Turbine
10,000-kw, 815 psi g, 900 F, 410 psi g exhaust pressure, 3600 rpm; 9 single-row stages, no extraction.
British - Thomson - Houston Company.

Superposed Generator
12,500 kv-a, 0.8 power factor, 4800 volts, 2 pole, 60 cycle, 3 phase.
British - Thomson - Houston Company.

Auxiliary Turbine
4000-kw cross-compound, 815 psi g, 900 F; h-p turbine 4000 rpm, 1-p turbine 3000 rpm; exhaust pressure 1 in. Hg abs.
De Laval Steam Turbine Co.

Auxiliary Generators
One 4000-kw 250 volt 360 rpm d-c.
General Electric Co.
One 2000-kw motor-generator set, 240 volt d-c, 4800 volt a-c, 450 rpm.
General Electric Co.

Auxiliary Condenser
One, 8000 sq ft, two pass, 2046 tubes, 15 ft 2¾ in long, 1 in OD, 18 gage. Cast-iron shell.
Worthington Pump & Mach. Corp.

Auxiliary Circulators
One 20-in horizontal double-suction volute pump, 10,000 gpm, 19 ft head, 435 rpm; General Electric motor, 37 to 60 hp, 215 to 435 rpm, 240 v, d-c.
Worthington Pump & Mach. Corp.

375 Lb 700 F Section

Main Turbines
50,000-kw, 375 psi g, 700 F, 1200 rpm; 21 single row stages; bled at 9th, 13th, 16th, and 19th stages.
General Electric Co.

Main Generators
62,500 kva, 0.80 power factor, 12,200 volt, 6 pole, 60 cycle, 3 phase.
General Electric Co.

Main Condensers
60,000 sq ft, single pass, 9680 tubes 24 ft 0 in long, 1 in OD, 18 gage.
Worthington Pump & Mach. Corp.

Main Circulators
Two per condenser, 48-in horizontal double-suction volute pump, two in operation, 120,000 gpm, 18.5 ft head, 230 rpm. General Electric d-c motor 150 to 400 hp, 175 to 240 rpm, 240 v.
Worthington Pump & Mach. Corp.

Main-Unit Vacuum Pumps
Laidlaw - Dunn - Gordon, two stage, single acting, 35x18 in. feather valve, 1500 cfm, 150 rpm. One per main unit. General Electric d-c motor, 14 to 66 hp, 60 to 150 rpm, 240 v.
Worthington Pump & Mach. Corp.

Oil Coolers
Duplicate, vertical type.
Andale Co.

Oil Filtration
Portable separator for main units, 300 gpm. Individual separators for auxiliary units, 300 gph.
De Laval Separator Co.

Batch Filter
Wm. W. Nugent & Co.

Generator Air Cooler
One per main unit, 10,680 sq ft cooling surface, 125,000 cfm.
Griscom Russell Co.

Generator Ventilating Fans
Internal-type, mounted on generator rotor.
General Electric Co.

Auxiliary Turbines
4000-kw cross-compound, 375 psi g, 700 F; h-p turbine 4000 rpm, 1-p turbine 3000 rpm; exhaust pressure 1 in. Hg abs.
De Laval Steam Turbine Co.

Auxiliary Generators
Three 4000-kw, 250 v, 360 rpm, d-c.
Crocker Wheeler El. Mfg. Co.
One 1000 kw motor generator, 300 volt d-c, 4800 v, a-c, 900 rpm.
General Electric Co.

Auxiliary Condensers
Three 7500 sq ft, two-pass, 2046 tubes, 14 ft 2½ in long, 1 in. OD 18 gage. Cast-iron shell.
Worthington Pump & Mach. Corp.

Auxiliary Circulators
Three—one each unit—20 inch horizontal double-suction volute pump 10,000 gpm, 19 ft head 435 rpm; General Electric motor, 37 to 60 hp, 215 to 435 rpm, 240 v, d-c.
Worthington Pump & Mach. Corp.

815 Lb 900 F Extension

Auxiliary Vacuum Pump
One 21x14 Laidlaw-Dunn-Gordon single acting, two-stage, horizontal, feather valve, 125 rpm, 350 cfm; General Electric motor 12 to 25 hp, 60 to 125 rpm, 240 v, d-c.
Worthington Pump & Mach. Corp.

Boilers
Special Stirling, single-ended bent-water-tube type, 950 psi g, 344,000 lb per hr normal full load capacity, 424,000 lb per hr maximum capacity; 8,188 sq ft saturated surface.
Babcock & Wilcox Co.

Water Walls
Bare tube surface, 3352 sq ft; partial stud-tube surface 1138 sq ft; bare block surface, 458 sq ft. Furnace volume 28,500 cu ft; heat release 15,800 Btu per hr per cu ft.
Babcock & Wilcox Co.

Superheaters
B & W, by-pass-compensating convection-type, pendant-loop design, 9353 sq ft surface, 910 F max steam temperature.
Babcock & Wilcox Co.

Economizers
Horizontal-return-bend counterflow type, 18,300 sq ft surface.
Babcock & Wilcox Co.

Air Heaters
Vertical bare tube type, two per boiler, 15,100 sq ft each, 30,200 sq ft per boiler, 357 F max air temperature.
Babcock & Wilcox Co.

Stokers
Taylor single-ended, underfeed type, 15 retort, 82 thin (57 standard) Noblo tuyeres, projected grate area 611 sq ft, coal burning capacity 44,000 lb per hr at maximum load. Philadelphia Gear Works two-speed reducing gear, ratios 4 to 1 and 10 to 1; General Electric motor, 120 and 240 v, d-c; 8¼ to 35 hp; 250 to 2,000 rpm. Clinker grinders, two rolls 26 in dia, 34 in dia over teeth; Westinghouse 240 v, d-c motor, 2½ to 5 hp, 500 to 2000 rpm, 2 rev per hr max speed of crusher rolls.
American Engineering Co.

Combustion Air Control
None.

Forced Draft Fans
Two fans per boiler driven from opposite ends of one motor. Each fan size 9½ DDHGS, double inlet, double width, Super-Duplex-Conoidal, rated 53,300 cfm each, 106,600 cfm per boiler, 15.7 in water static pressure, 1000 rpm. Westinghouse motor 240 v, d-c, 500 to 1000 rpm, 56 to 450 hp.
Buffalo Forge Co.

Induced Draft Fans
One fan per boiler, size 13 DDHGS, double inlet, double width Super Conoidal, rated 189,000 cfm at 15.5 in water static pressure, 350 F gas, 975 rpm. Westinghouse motor, 240 v, d-c, 488 to 975 rpm, 94 to 750 hp.
Buffalo Forge Co.

Soot Blowers
Welded, integral-type, special deslagging nozzles. All piping within boiler setting.
The Detroit Edison Co.

375 Lb 700 F Section

Auxiliary Vacuum Pump
Three—one each unit—21x14 Laidlaw-Dunn-Gordon single acting, two-stage, horizontal, feather valve, 125 rpm, 350 cfm; General Electric motor 12 to 25 hp, 60 to 125 rpm, 240 v, d-c.
Worthington Pump & Mach. Corp.

Cranes
Turbine room, 125 tons capacity, 96 ft 11½ in span, 74 ft 1 in lift. Auxiliary bay, 35 tons capacity, 24 ft 8½ in span, 50 ft lift.
Harnischfeger Corp.

Boilers
Special Stirling, single ended, bent-water-tube type, 455 psig, 340,000 lb per hr normal full load capacity, 427,000 lb per hr maximum capacity; 23,900 sq ft saturated surface.
Babcock & Wilcox Co.

Water Walls (Screen Boiler)
Effective bare wall tube surface 2,044 sq ft; Bailey block surface 1,456 sq ft; furnace volume 13,800 cu ft; heat release 32,000 Btu per hr per cu ft.
Babcock & Wilcox Co.

Superheaters
B & W hairpin, convection type, 4,900 sq ft, 700 F steam temperature.
Babcock & Wilcox Co.

Economizers
Wrought steel, horizontal return bend, counterflow type, 6,032 sq ft surface.
Babcock & Wilcox Co.

Air Heaters
Vertical bare-tube type, 26,920 sq ft surface, 350 F maximum air temperature.
Babcock & Wilcox Co.

Stokers
Taylor, single-ended, underfeed type, 15 retort, 57 standard tuyeres, projected grate area 611 sq ft, coal burning capacity 44,000 lb per hr at maximum load. Cleveland Worm and Gear Co. reduction gear 4 1/7 to 1 ratio, General Electric Co motor, 120 and 240 v, d-c, adjustable speed, 250 to 2,000 rpm, 8¼ to 25 hp. Clinker grinders, two rolls, 26 in dia. 34 in dia over teeth. General Electric Co. 240 v, d-c motor 500 to 2,000 rpm, 2½ to 5 hp. 2 rev per hr max speed of crusher roll.
American Engineering Co.

Combustion Air Control
Automatic zoned air control. Automatic metered control on No. 2 boiler only.
American Engineering Co.
The Detroit Edison Co.

Forced Draft Fans
Two fans per boiler, driven from opposite ends of one motor. Each fan size 9½ DDHGS, double inlet, double width. Super-Duplex Conoidal, rated 65,000 cfm each, 130,000 cfm per boiler, 12.5 in water static pressure, 925 rpm General Electric motor 240 volt, direct current, 450 to 925 rpm, 50 to 400 hp.
Buffalo Forge Co.

Induced Draft Fans
One fan per boiler, size 13 DDHGS, double inlet, double width Super Conoidal, rated 233,000 cfm at 13.9 in water static pressure, 350 F gas, 930 rpm. General Electric motor, 240 volt, direct current, 450 to 930 rpm, 80 to 700 hp.
Buffalo Forge Co.

Soot Blowers
The Diamond Power Specialty Corp.

Principal Equipment at the Delray Plant—Continued

815 Lb 900 F Extension	375 Lb 700 F Section
Water Columns The Diamond Power Specialty Corp.	**Water Columns** Four per boiler. Yarnall-Waring Co.
Stacks Two boilers per stack, self-supporting steel. Muskegon Boiler Company fabricators. The Detroit Edison Co. erectors.	**Stacks** Two boilers per stack, self-supporting, steel. The Youngstown Boiler and Tank Co.
Stage Heaters High-pressure, six-pass condenser type with desuperheat zone, welded steel-plate construction, breech-block head, water pressure 1200 psi g, ⅝ in dia tubes, 10 gage. Low-pressure four-pass condenser type, welded steel-plate construction, bolted head, water pressure 250 psi g, ⅝ in dia tubes, 18 gage, Surface, 4th and 7th, 3535 sq ft each; 10th, 2935 sq ft; 13th, 2640 sq ft, drain cooler, 1026 sq ft. The Griscom-Russell Co.	**Stage Heaters** High-pressure, four pass condenser type, Units 11 and 12 are riveted steel plate construction, Unit 13, welded construction, bolted heads, water pressure 600 psi g, ⅝ in dia tubes 16 gage. Low-pressure, four pass condenser type, Units 11 and 12 are riveted steel plate construction, Unit 13 is welded construction, bolted heads, water pressure 150 psi, ⅝ in dia tubes, 18 gage. Surface 9th stage 2550 sq ft; 13th, 2545 sq ft; 16th, 2780 sq ft; 19th, 2415 sq ft. The Griscom-Russell Co.
Evaporators Horizontal, welded-steel shell, submerged type, single effect, self-scaling, bent-tube; 204 sq ft heating surface; 45.9 sq ft disengaging surface; capacity 10,300 lb per hr. The Griscom-Russell Co.	**Evaporators** One per main unit; horizontal, riveted steel shell, submerged Reilly-coil type, single effect, self-scaling. 283 sq ft heating surface. Capacity 8750 lb per hr. The Griscom-Russell Co.
Combination Pumps Boiler-feed and hotwell pumps, two per main unit; motor-driven, BFP 1455 gpm, 1015 lb pressure, HWP 1565 gpm, 204 lb pressure, 1770 rpm; Westinghouse motor, 1500 hp, 1452 to 1785 rpm, 4800 v, 3-phase, a-c, slip ring induction. Turbine-driven, BFP 1455 gpm, 1015 lb head; HWP 1565 gpm, 222 lb head, DeLaval turbine, 1438 hp, 1770 rpm. DeLaval Steam Turbine Co.	**Combination Pumps** Boiler-feed and hotwell pumps, two per main unit, motor-driven, BFP 1360 gpm, 1195 ft head, 1175 rpm, HWP 1500 gpm, 290 ft head, 1175 rpm, Crocker-Wheeler motor, 425 to 700 hp, 1000 to 1200 rpm, 240 v, d-c. Turbine-driven, BFP 1360 gpm; 1225 ft head; 1650 rpm HWP, 1500 gpm; 209 ft head. De Laval turbine, 602 hp, 1700 rpm. DeLaval Steam Turbine Co.
Lift Pump One per main unit, 1565 gpm, 47 ft head, 600 rpm; General Electric motor, 30 hp, 600 rpm, 240 v d-c. DeLaval Steam Turbine Co..	**Lift Pump** One per main unit; 1500 gpm; 50.5 ft head; 600 rpm General Electric motor, 30 hp, 600 rpm, 240 v, d-c. DeLaval Steam Turbine Co.
Heater-Drain Pump One per main unit, 287 gpm, 193 lb pressure, 1750 rpm; Westinghouse motor, 60 hp, 1750 rpm, 220 volt 3-phase, 60 cycle squirrel cage. DeLaval Steam Turbine Co.	**Heater-Drain Pump** One per main unit; 400 gpm, 320 ft head, 1800 rpm General Electric motor, 15 to 60 hp, 1200 to 1800 rpm, 240 v, d-c. DeLaval Steam Turbine Co.
Superposed Unit Booster Feed Pump 1185 gpm, net pressure 585 psi, 350 F, 2475 rpm. DeLaval speed increasing gear 1185 to 2475 rpm. Westinghouse 240 v, d-c motor, 400 to 700 hp, 1000 to 1200 rpm. DeLaval Steam Turbine Co.	
Auxiliary-Unit Hotwell Pump One per unit; 150 gpm, 185 ft head, 1750 rpm. General Electric motor, 25 to 30 hp, 1200 to 1600 rpm, 240 v, d-c. Worthing Pump & Mach. Corp.	**Auxiliary-Unit Hotwell Pump** One per unit; 160 gpm, 95 ft head, 1500 rpm General Electric motor, 10 hp, 1500 rpm, 240 v, d-c. Worthington Pump & Mach. Corp.

COMMON TO BOTH SECTIONS

Condensate-Storage Tanks
Welded-steel construction. Four installed, 47,000 gal. each.
The Detroit Edison Co.

Hot-Drip Pumps
Three installed; 250 gpm, 125 ft head, 1750 rpm; General Electric motors, 2 to 15 hp, 920 to 1840 rpm, 240 v, d-c.
DeLaval Steam Turbine Co.

Heating Return Pumps
Three low-level pumps—Jennings; two of 35 gpm each, one 9 gpm; General Electric motors; two, 2 hp 1740 rpm; one, 1 hp 3490 rpm, 220 v, 3-phase, 60 cycle, induction.
Nash Engineering Co.

PIPING AND VALVES

815 Lb 900 F Extension	375 Lb 700 F Section
Pipe and Pipe Fabrication National Tube Co. Crane Co. Murray W. Sales Co. The Detroit Edison Co.	**Pipe and Pipe Fabrication** Pittsburgh Piping and Equipment Co. Benjamin F. Shaw Co. M. W. Kellogg Co. Murray W. Sales Co.
High-Pressure Superheated Steam Parallel-Slide Gate Valves Lunkenheimer Co. Valve Motor Operators Cutler-Hammer Inc. Stop-and-Check Valves Schutte & Koerting Co.	**High-Pressure Superheated Steam** Parallel-Slide Gate Valves Chapman Valve Mfg. Co. Valve Motor Operators Chapman Valve Mfg. Co. Stop-and-Check Valves Schutte & Koerting Co.
High-Pressure Boiler-feed and Saturated Steam Wedge-Gate Valves Lunkenheimer Co.	**High-Pressure Boiler-feed and Saturated Steam** Wedge-Gate Valves Chapman Valve Mfg. Co.
Feedwater Regulators One per boiler, Copes valves with tension-type thermostat, automatic constant-pressure-drop regulation, capacity 433,000 lb per hr. Northern Equipment Co.	**Feedwater Regulators** Two per boiler, Copes valves with tension-type thermostat, 300,000 lb per hr capacity each. Northern Equipment Co.
Safety Valves Six 3-in pop safety valves per boiler, average capacity 65,000 lb per hr each of saturated steam. Two 3-in per superheater, average capacity 44,600 lb per hr each of superheated steam. Consolidated Ashcroft Hancock Co., Inc.	**Safety Valves** Twelve 4-in valves per boiler, capacities from 49,700 to 52,700 lb per hr each of saturated steam. Two 4-in valves per superheater, 46,600 lb per hr. each. Consolidated Ashcroft Hancock Co., Inc.
Blow-off Valves 2 per boiler. Lunkenheimer Co.	**Blowoff Valves** Four 2½-in valves per boiler. J. Hopkinson & Co., Ltd.
Miscellaneous Small High-Pressure Valves for Drains, By-passes, Instruments, and so on. Globe Valves Lunkenheimer Co. Consolidated Ashcroft Hancock Co., Inc.	**Miscellaneous Small High-Pressure Valves for Drains, By-passes, Instrument Lines, and so on** Globe Valves. Consolidated Ashcroft Hancock Co., Inc.
Miscellaneous Low-Pressure Valves and Regulators Jenkins Bros. Reading, Pratt & Cady Co. D. T. Williams Co. William Powell Co. Walworth Co. Atwood and Morrill Co. Chapman Valve Mfg. Co. Consolidated Ashcroft Hancock Co., Inc. Crane Co. Fisher Governor Co. Lunkenheimer Co. Ruggles-Klingemann Mfg. Co.	**Miscellaneous Low-Pressure Valves and Regulators** Jenkins Bros. Reading, Pratt & Cady Co. D. T. Williams Co. William Powell Co. Walworth Co. Atwood and Morrill Co. Chapman Valve Mfg. Co. Consolidated Ashcroft Hancock Co., Inc. Crane Co. Fisher Governor Co. Lunkenheimer Co. Ruggles-Klingemann Mfg. Co.
High-Pressure Steam Traps—Impulse Type Yarnell-Waring Co.	**High-Pressure Steam Traps** Armstrong Machine Works

INSTRUMENTS

Indicating and Recording Pressure Instruments
Ashton Valve Co.
Bristol Co.
Consolidated Ashcroft Hancock Co., Inc.

Mercury Column Vacuum Gages
Taylor Instrument Cos.

Draft Gages
Hays Corp.

Indicating and Recording Temperature Instruments
Bristol Co.
Cambridge Instrument Co., Ltd.
Consolidated Ashcroft Hancock Co., Inc.
General Electric Co.
Leeds and Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.
Weston Electrical Instrument Co.

Flow Meters
Bailey Meter Co.
Builders Iron Foundry

Water Level
Crane Co.
The Liquidometer Corp.
Diamond Power Specialty Corp.

Stoker Tachometers
The Electric Tachometer Corp.

Turbine Signal System
Electric Indicator Corp.

Superheater Damper-Position Indicators
The Detroit Edison Co.

CO_2 and CO Metering Equipment
Bacharach Industrial Instrument Co.

COAL HANDLING EQUIPMENT

Drag-Line Scraper
R. H. Beaumont

Drag-Line Cable
A. Leschen and Sons

Rotary Car Dumper
Capacity, fifteen 120-ton cars per hr; General Electric motor, 80 hp, 220 v, a-c.
Wellman-Seaver-Morgan

Coal Crushers
Two Bradford-type breakers, 12x22 ft, 14 rpm, 525 tons per hr each; General Electric motor, 150 hp, 720 rpm, 220 v, a-c.
Pennsylvania Crusher Co.

Conveyors
Link-Belt Co.
Robins Conveying Belt Co.

Coal Unloading Dock
The Detroit Edison Co.

Dust Collecting System
Dracco bag filters.
Dust Recovering and Collecting Co.

Waterman Station

Circuit Breakers
Type FH-209-C, 600 and 3000 amp, 35 kv, 40,000 amp interrupting capacity, motor operated.
General Electric Co.
Deion, 600 amp, 35 kv, 40,000 amp interrupting capacity, solenoid operated.
Westinghouse El. & Mfg. Co.

Circuit Buses
Original section. 2—4 in x ¼ in copper bars, rated 1400 amp at 35°C rise.
Later section. 3—6 in x ¼ in copper bars, rated 2400 amp at 35°C rise.

System Tie Buses
2—6 in x 0.437 in web aluminum channels, rated at 3200 amp at 35°C rise.

Equalizer Bus
Earlier section. 3—6 in x ¼ in copper bars, rated at 2400 amp at 35°C rise.
Later section. 2—6 in x 0.437 in web aluminum channels, rated at 3200 amp at 35°C rise.

Breaker and Bus Housings
Breakers and circuit buses in original section are housed in masonry cells integral with the building.
Breakers and circuit buses in later section and all system tie and equalizer buses have three phase, metal housings with metal baffles between phases, the complete unit being insulated from the building and from adjacent units. Copper or aluminum in combination with steel is used for heavy currents, steel alone for light currents.

Equalizer Reactors
Indoor dry type, each phase enclosed in metal case, insulated from building.
For generators, 2500 kva, 1800 amp, 24 kv circuit voltage.
General Electric Co.
For system ties, 2666 kva, 2400 amp, 24 kv circuit voltage.
Metropolitan Device Corp.

Relays
For Fault Bus Protection—Instantaneous, overcurrent, type PQ 29 Y2. General Electric Co.
For Bus Differential Protection—Instantaneous, overcurrent, type PQ. General Electric Co.
For Generator Differential Protection—Ratio-differential, Type CA, Westinghouse El. & Mfg. Co. Also instantaneous, overcurrent, type PQ, General Electric Co.
For Regulating Transformer Differential Protection — Instantaneous, overcurrent, type PQ, also time delay, type IAC, General Electric Co.
For Parallel Feeder Protection —Balanced-current, type PD3, also Time delay with instantaneous attachment, overcurrent, type IAC. General Electric Co.
For Radial Feeder Protection —Combined instantaneous and inverse time, type RI. Condit Electrical Mfg. Co.

Switchboard
Vertical, marble panels for control, instruments and relays. The Detroit Edison Co.

sure. If, under such conditions, the superposed machine should trip out, the steam pressure in the 400-lb steam mains would fall rapidly. At the same time the steam admission valve of the low-pressure condensing unit would automatically open to admit more steam in an effort to carry load at the reduced pressure and thus drop the steam pressure still further. Before the 400-lb boilers could pick up the load, the pressure on this part of the system would almost inevitably fall to a dangerous point involving both boilers and steam auxiliaries, and with disastrous results. Such

TABLE II—MAIN-TURBINE DATA

	First Section	Extension	
Turbine Unit No.	11, 12, 13	14, 15, 16	21
Throttle Press psi g	375	815	815
Throttle Temp F	700	900	900
Exhaust Press	1 in. Hg	1 in. Hg	410 psi g
Speed, rpm	1200	1800	3600
Rated Capacity, kw	50,000	75,000	10,000
Number of Pressure Stages	21	17	9
Bled stages	9, 13, 16, 19	4, 7, 10, 13	none
Max Feedwater Temp	350	390	350
Max Throttle-steam flow lb/hr, each unit	605,000	652,000	504,000
Type of governing	throttle and overload	Partial admission 8 valves	Partial admission 8 valves
Casings	Single	Single	Single

a disturbance might have far-reaching effects in upsetting the supply of direct-current to essential auxiliaries, such as forced and induced-draft fans, since the backbone of the d-c system is the turbine driven geared generators. Three of these units operate on 400-lb steam and only one of them on 815-lb steam. Furthermore the high-pressure d-c unit will not be installed until some considerable time after the superposed unit is available. The principal object in automatically decreasing the load on the 50,000-kw units is, then, to maintain the supply of steam to the direct-current machines, although it is hoped that under such circumstances it will be possible to catch up on steam supply without actually taking the 50,000-kw machine off the line. In any event, the electrical system as a whole stands always ready to lose a large machine, as has been discussed in connection with "firm capacity," whereas it is vital to the continued operation of the entire power plant that a supply of steam to the house-service machines be maintained.

TABLE III—MAIN-GENERATOR DATA

	First Section	Extension	
Unit Number	11, 12, 13	14, 15, 16	21
Generator capacity, kw	50,000	75,000	10,000
Power Factor	0.8	0.75	0.8
Continuous rating, kva	62,500	100,000	12,500
Terminal voltage	12,200	14,400	4,800
Short circuit ratio	1.21	1.0	0.665
Poles	6	4	2
Speed, rpm	1,200	1,800	3,600
Closed air circu'n, cfm	125,000	130,000	27,000
Exciter voltage	250	250	125
Max excit current, amp	1,200	1,000	300

In order that the operators at the Waterman switching station may know of conditions in the boiler room, a pressure gage will be installed in the control room there, to indicate the pressure of steam supplied to the 400-lb units. This pressure gage is equipped with an alarm set at 350 psi g.

A cross-sectional view of the superposed turbine is shown in Fig. 13, while the governing scheme is illustrated diagrammatically in Fig. 14.

Experience with other 3,600 rpm machines carried on the steel structure of the building, has indicated the need for a means of absorbing vibration, inherently stronger in a two-pole machine than in one of four or six poles. The Detroit Edison Company has built a number of successful spring bases for geared house-service turbo-generators, and with this background of experience it was decided to construct a spring supported base for this machine. In this way the building steel, though it carries the unit, is insulated from vibrations set up by the two-pole generator.

Design features of all the main turbines and generators in the Delray Plant are summarized in Tables II and III, respectively.

(Part II of this series will be published in the May issue of POWER PLANT ENGINEERING.)

Characteristics of metal and asbestos ducts in a form suitable for use by designers of air conditioning systems presented before the last annual meeting of the A.S.R.E.

Asbestos Ducts and Air Conditioning Systems

By R. H. HEILMAN
Mellon Institute of Industrial Research
Pittsburgh, Pa.
and
R. A. MACARTHUR
The Philip Carey Mfg. Co.
Lockland, O.

RECENTLY DEVELOPED all-asbestos insulating air conditioning ducts are having a steadily increasing acceptance in the air conditioning field. They are available in either round or rectangular cross-section in units 3 ft. in length. Each unit consists of a hard inner tube or core 3/16 in. in thickness, made of laminated asbestos paper and an outer jacket closely fitted on the core and made of cellular asbestos paper wound in layers to the proper thickness.

Figure 1, plotted on logarithmic paper, gives the drop in static pressure obtained on the various ducts tested. The static pressure drop corrected to a 100-ft. length is plotted against the average velocity measured at the downstream end of the duct. This shows that the curves of velocity against pressure drop for the various duct sizes are parallel to each other and have a slope of approximately 1.87 or that the pressure drops vary, within 1 per cent directly, at $V^{13/7}$.

When the pressure drops obtained on the asbestos ducts were plotted on rectangular coordinate paper against the reciprocal of four times the hydraulic radius it was found that a straight line could be drawn through the plotted points which had a maximum deviation of less than eight per cent from any of the points. The same was found to be true for the round metal ducts, although the line obtained did not fall on the line obtained for the asbestos ducts but was parallel to it.

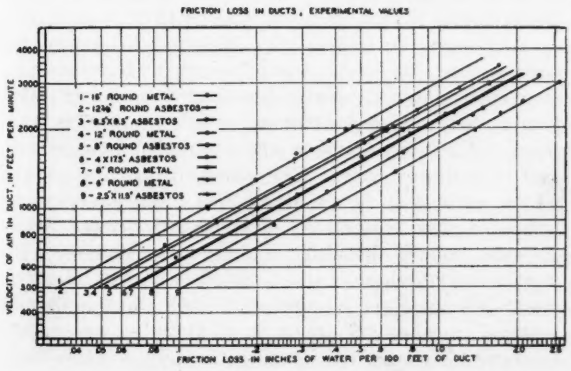

FRICTION LOSS IN DUCTS, EXPERIMENTAL VALUES
VELOCITY OF AIR IN DUCT, IN FEET PER MINUTE
1 - 15" ROUND METAL
2 - 12½" ROUND ASBESTOS
3 - 8.5"X8.5" ASBESTOS
4 - 12" ROUND METAL
5 - 8" ROUND ASBESTOS
6 - 4"X12.5" ASBESTOS
7 - 6" ROUND METAL
8 - 6" ROUND METAL
9 - 2.5"X11.5" ASBESTOS
FRICTION LOSS IN INCHES OF WATER PER 100 FEET OF DUCT

Fig. 1. Friction loss in 100 ft. of ducts of various types and shapes

Figure 2 was constructed from the above relationships of velocity and diameter or hydraulic radius. The hydraulic radius is defined as the quotient of the area divided by the perimeter of the wetted surface, or, for a rectangular duct, R is ab / (a + b) and for a cylindrical duct, R is D / 4. Therefore, the diameter D of a round duct equals 4R or 4 times the hydraulic radius.

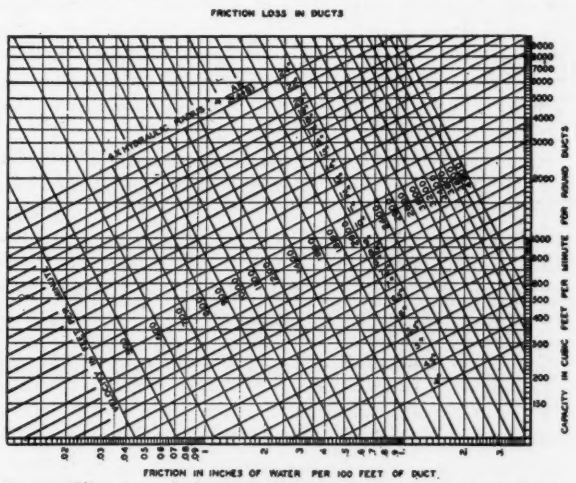


Fig. 2. Chart for calculating friction losses in air conditioning ducts

This chart gives the pressure drop in inches of water for a 100-ft. length of asbestos duct and may be used for either rectangular or round ducts. In using the chart for rectangular ducts the pressure drop is obtained by multiplying R by 4 and by following the line in the curve corresponding to this

Table I. Thickness of asbestos duct required to prevent sweating

Percent relative humidity	*Difference in temperature between air inside and outside of duct*						
	20°F.	*25°F.*	*30°F.*	*35°F.*	*40°F.*	*45°F.*	*50°F.*
60	½ in.	½ in.	½ in.	¾ in.	¾ in.	1 in.	1 in.
70	½ "	¾ "	1 "	1¼ "	1½ "	1½ "	1¾ "
80	1¼ "	1½ "	1¾ "	2 "	2½ "	2¾ "	3 "

diameter to the point where it crosses the desired velocity line and dropping down vertically to the bottom of the scale where the pressure drop is obtained directly.

Example: Determine the pressure drop in 100 ft. of 8½ by 14½ in. asbestos duct when air is flowing through the duct at a velocity of 1600 ft. per min. Solution: R is 10.72, which gives a pressure drop of 0.355 in. of water. The pressure drop would also be 0.355 in. for a 10.72 in. diameter asbestos round duct carrying air at a velocity of 1600 ft. per min. or a volume of 1000 cu. ft. per min.

The chart cannot be used for round metal ducts of the usual construction owing to the fact that the frictional resistances in these ducts is somewhat higher than would be obtained by the use of the chart. On the other hand, data obtained previously on rectangular metal ducts indicates that the losses in well-made metal ducts fabricated from units six or eight feet long and joined with lock strips may be taken from the chart of Fig. 2.

As noted above, the chart, Fig. 2, may be used to calculate the friction losses in either rectangular metal or round and rectangular asbestos ducts. The capacities for round ducts at various velocities may be read from the chart. While the friction losses for rectangular ducts of various sizes and at various velocities may be read from the chart, the capacities are to be calculated from the cross-sectional area by obvious methods.

Thermal conductivity values obtained on samples of asbestos ducts were 0.622 B.t.u. per sq. ft. per hr., per in. of thickness per degree F., at a mean temperature of 50 deg. F. and 0.707 B.t.u. at a mean temperature of 150 deg. F. The conductivity at mean temperatures between these two values is a straight line function of the mean temperature. The thermal transmission coefficient U for various temperature conditions, etc., can be calculated from the standard formula.

Sweating

It is often necessary in air cooling installations to know the thickness of asbestos or insulation which will prevent sweating or condensation on the outer surface of the duct. Sweating will be prevented when the thickness of the duct is sufficient to raise the temperature of the outer surface to a point slightly higher than the dewpoint for the corresponding air temperature and relative humidity. Table I has been calculated for rectangular asbestos ducts carrying air at 50 deg. F. for temperature differences between the air inside and outside the ducts of 20 to 50 deg. F., or corresponding to room temperatures of 70 to 100 deg. F.

The attenuation of sound in metal and asbestos ducts of various sizes and shapes has been measured by "practical" methods. All the data considered desirable for proper evaluation of the attenuation in ducts of all dimensions have not as yet been obtained, and the following results are to be considered only indicative of general behavior.

Improvement in sound reduction of asbestos ducts over metal ducts is substantially constant with velocity. At a velocity of 1000 f.p.m., the sound levels obtained at the outlet of the ducts were lower with asbestos ducts than with metal ducts by the following amounts: 11 by 13 in. ducts, 6.0 decibels; 5½ by 8½ in., 517 decibels; and 2½ by 11 in., 8.8 decibels.

Fittings will in general contribute to the reduction of sound. Data show that an asbestos 90 deg. elbow of inside dimensions 5½ by 8½ in. attenuated sound of frequencies 250, 500 and 1000 cycles, 7, 11 and 14 decibels, respectively, more than a metal elbow of the same cross-section and of radius ratio 1.5. The metal elbow reduced the sound practically not at all. An 8½ by 8½ in. abestos elbow reduced the sound 7.8, 7.2 and 12.2 decibels at the respective frequencies.

With air flow, the 5½ by 8½ in. asbestos elbow reduced sound at the outlet 4 and 7 decibels more than the metal at 500 and 1000 f.p.m. At ordinary velocities valuable sound reduction may be expected from asbestos duct systems containing several fittings. There are no appreciable resonance effects with asbestos ducts and sound pick-up from the environment, and particularly the transmission of such sound, is much less than in metal ducts.

Electrical Voice Operated Telephone

A NEW telephone instrument which gets its power solely from the speaker's voice and enables the user to call any of five other stations has been announced by the Western Electric Co., 195 Broadway, New York, N. Y. The electrical voice current is generated internally by the impact of sound waves on a special diaphragm and hence it is independent of external power. A self-contained, hand operated generator provides for signaling.

To place a call, the user turns a simple rotary-selector switch to the station desired and spins a small signaling crank on the side of the instrument. This causes the distant telephone to emit a high-pitched tone signal of great penetrating power.

Although the device was designed primarily for marine use, its water-tight, weather-resistant construction adapts it ideally for service in construction camps, warehouses, factories or other exposed locations. All internal parts are assembled in a sealed, cast aluminum case. The transmitter diaphragm, which mounts in front of an aluminum cover plate, is coated with a non-corrosive, moisture-proof finish. A soft rubber housing encloses the receiver, the diaphragm of which is also finished to withstand corrosion. The receiver is connected with the telephone's internal mechanism through a flexible, waterproof cord which enters the housing through a water-tight gland.

Readers' Conference

These pages are open to readers for the presentation or discussion of any timely power plant topic. The Editors invite your participation.

Reconditioning Oil

In the February issue of Power Plant Engineering there is a statement by W. F. Schaphorst, of Newark, N. J., entitled, "Reconditioned Lubricating Oil," that I believe to be incorrect in implying that lubricating oil cannot be successfully reclaimed.

I have had 20 yr. of very close association with a concern that manufactures apparatus for this class of work. I can say that this is possible, both from a practical and an economical standpoint, this can be proven by technical information in my possession, and by any number of successful installations in practically every state in the Union, and in many foreign countries.

The successful use of reclaimed oil depends entirely on the open mindedness of the operator, or user, because the proper use of this reclaimed oil will result in lower lubrication costs, and lower maintenance costs.

To obtain these results several things must be borne in mind, chief of which will be the class of equipment served, and the type of oil reclaiming equipment used. This is very important as so many poor methods and products have been marketed in the last few years that I can readily understand Mr. Schaphorst ideas on oil reclaiming.

I can personally state that there are very many installations on gas, gasoline, and Diesel engines. The performance of these engines has been increased from an operating standpoint by giving more time between overhauls and a much smaller cost for lubrication. These are two very important items in the cost of operating any equipment.

If the proper viscosity, fire and flash points are maintained, and are as constantly checked as they are in new oil, then the results will be equal to that of new oil. This is amply confirmed by laboratory tests conducted by several of the large oil companies. universities, and commercial laboratories, also the hundreds of commercial installations prove the reliability of reconditioned oil.

As far as I personally know there is only one type of oil reclaiming equipment that has been uniformally successful. This type of reclaimer uses the distillation—filtration process which is practically the same process used in all the commercial refineries of the United States.

Mr. Schaphorst refers to the high sulfur content of reclaimed oil, I would like to state that if the proper method is used this condition will disappear, and not be aggravated as is the ease with some processes that are on the market at present.

Chicago, Ill. R. G. Dickens.

Cost of Belt Slip

In drawing attention to the cost of belt slip in the February issue, N. G. Neer has rendered a much needed service, but in estimating the value of the fuel loss, he seems to have made an error, perhaps of a typographical nature.

On the basis of his own figures, the total loss due to 2 per cent slip, is, as Mr. Neer correctly states, $50,400,000, but he goes on to state that this represents $50,000,000 in fuel.

At $42.00 per hp. yr., of 308 ten-hour days, the cost is about 1.36 cents per hp-hr. or 1.81 cents per kw hr.

In view of the fact that many public utilities pay twice as much for taxes alone as they do for fuel, it is quite clear that with power selling at 1.81 cents per kw-hr., a fuel cost of more than ½ cent would be absoluely prohibitive, however, to be on the safe side, we will assume such a cost.

Mr. Neer predicates a total load of 60,000,000 × 308 × 10, or 184,800,000,000 hp-hr., which is equal to 137,860,800,000 kw-hr. A 2 per cent loss on this, is 2,757,216,000 which at ½ cent, amounts to $13,786,080 which is very different from $50,000,000.

Of course, many private plants have a fuel cost chargeable to power, considerably in excess of ½ cent per kw-hr., at the same time there are others where, owing to the economical use of exhaust steam, the charge is a good deal less than this, so ½ cent would appear to be a conservative average figure for all power.

There is no doubt that the total loss throughout the country, due to faulty transmission, is entirely too high, and it is very important that the entire subject should be given more consideration; on the other hand, there is always more than one point of view, and it is fundamental in good engineering that all points of view should be given full consideration.

Unfortunately, owing to the fact that we engineers are, of necessity, more or less specialists, we too often fail to do this. We have a perfectly good case from our own standpoint, but we fail to see that it may have an entirely different appearance from others.

Let us, for instance, look at the question of a 2 per cent belt slip, from the point of view of a small manufacturer, spending $2000 a year, for belt transmitted power, the rest being direct drive.

We call upon him and point out that he is losing 2 per cent through avoidable belt slip. Unfortunately for our argument, this only amounts to about 80 cents a week, but we are pretty convincing talkers, so he decides to call in his shop superintendent and hold a conference.

After we have spent the best part of the morning arguing about the matter, the manufacturer suddenly wakes up to the fact that we have already spent about three months' savings in talk alone, and haven't really started anything yet, and then, too, if he does get things tuned up, who is going to keep up the good work, so he decides to let well enough alone, and not worry about the 80 cents, and can you blame him?

In the case of large plants which employ a maintenance superintendent and crew, the case is different, but even there, it costs something, though probably the cost is more than justified.

It is very unfortunate that engineering advice is generally of no practical value unless someone is ready to spend money on the strength of it. This is an important fact to keep in mind, and the real question is, looking at it from all angles, will the investment justify itself? Very often the correct answer involves many factors which lie outside the realm of engineering.

This is not a plea for carelessness, or inexcusable waste, but it is a plea for a realistic approach, for it is the absence of a realistic approach which makes so many people suspicious of engineering advice, especially when they have to pay for it.

Bloomfield, N. J. JAMES O. G. GIBBONS.

License Laws

I HAVE just read the article on "Engineers Licenses" in the February issue of this magazine by Mr. Rutherford. In order that readers may be informed, I would state that the Stationary Engineers License Law in Ohio, was passed about 39 yr. ago to protect lives and property. Familiar as I am with this law, I do not know how any organization or society could create vacancies which they hope to fill with unemployed members of their respective organizations or societies by sponsoring movements pertaining to educating and licensing engineers.

As for memorizing a few questions and answers to obtain an Engineer's License, this I think would be a very foolish way of going about obtaining one. These memorized answers would be identical to a mechanical man who performs various motions when certain words are pronounced and is at an entire loss when shifted off the predetermined routine.

The engineers license should be to the people, as a whole, just as the doctors, the dentist, the pharmacist certificate and license. I know any man with the least of common sense would not tolerate the unlicensed practicing of any of these vital professions.

I agree that most of the progressive industries do pay tuitions in whole or in part for any employee who wishes to benefit the company as well as himself. I also know of a superintendent in charge of a large steam power plant who will not tolerate a change in days off to permit a man to attend school one night a week, this being necessary just eight times in three months and neither inconveniences nor works a hardship on any one.

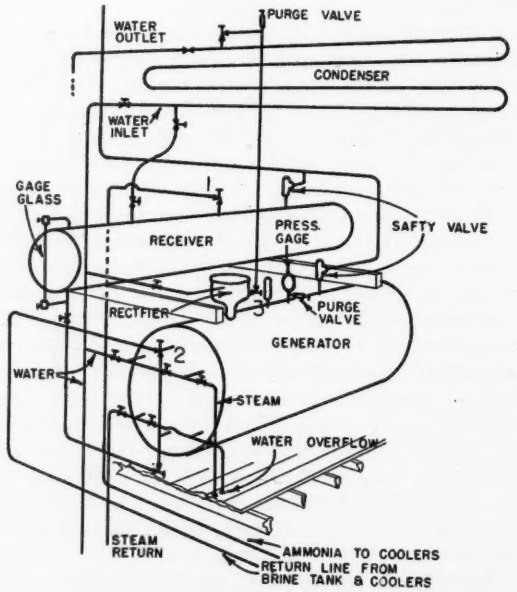
To quote Mr. Tarquin De Rosa in the February issue of this magazine, "most industrial plants regard the power plant as a necessary evil, therefore it is usually the last department improved upon or modernized." It won't be long until the inefficiently operated steam power plant will be another victim of efficiency.

Fort Thomas, Ky. WALTER J. HARVEY, JR.

Importance of Pure Cooling Water for Power Plants

WHEN IMPURE water is used for cooling ammonia generators of the absorption type such as are commonly used in power plants, a typical example of which is illustrated here, there is a possibility of getting into considerable trouble and expense. Several times in this writer's experience the cooling coils in the generator have become completely clogged with scale. When that happens the only remedy is to install new oils, and that is an extremely costly process because bolted and riveted generators have been tried and they almost invariably leaked. Alternate heating and cooling is "too much" for unwelded vessels to endure. Therefore, being welded, that means that one of the ends must be cut off either by the torch or sawing process, the tubes removed, new ones inserted, and then everything put together again.

When you consider that this involves not only the cutting in two and rewelding of the generator, but



Typical connections for an absorption plant

the removal of insulation, much disassembling of parts, and then putting everything together again with the replacement of the insulation, you can see why there are few repair jobs that are more expensive.

Clearly, the obvious remedy is to avoid such an occurrence by using cooling water that is as pure as can be obtained. If your water is not pure, if you are using a generator of this type, and if you are not treating the water, it will usually pay to consult a reliable water treating specialist.

Newark, N. J. W. F. SCHAPHORST.

Modern Methods of Plant Engineering

PLANT ENGINEERING today becomes a more complex problem than ever before, as we try to keep up with a fast moving world. The plant engineer is generally thought of as a man who keeps the machinery moving and maintains the plant in general—a man who can work 24 hr. a day, during numerous emergencies, and be in readiness for day and night calls seven days a week from year to year. We still have organizations of this type in existence, but they are becoming a thing of the past.

The plant engineer of today should have technical training, and a resource of practical knowledge obtained from experience. He should train men for more than one job, so that emergency calls are not all placed on the shoulders of one man. In a modernizing program or in the maintenance of plant equipment, cost records are essential to the plant engineer. This will give him the confidence to show the management in a clear, simple manner why improvements should be made. Therefore the plant engineer will be consulted before new equipment is bought, avoiding costly mistakes, as each factory or power plant has its own peculiar characteristics.

Sales engineers at times get too enthusiastic about their product, trying to fit their particular product into a standard form, then the local plant engineer should be able to choose, and determine what he needs, from different equipment manufactures, who are always willing to co-operate with him. He should then be able to design and layout the unit as a whole, thereby creating facilities that will be efficient and practical for their special use.

The writer has in mind an installation which consisted of changing a 150-hp. electric motor driven paper beater from a chain drive to a V-belt drive. This was something quite new at the time the change was undertaken, on a job of this size. After a number of failures on the first installation the plant engineer persuaded the management to try his idea of a complete new method, using the same equipment, which was undertaken and proved to be successful. Sometimes an expensive failure is necessary, so that the plant engineer can prove his ability. In reality the factory and power plant is the proving ground where defects in design, that sometimes are not found in shop or model tests, show up.

The success of a plant engineer depends on his ability to select and train men who are dependable, for various positions in the machine shop and maintenance crew. In the majority of plants very little if any of the maintenance work will have to be sent out to be done. Good savings in money and plant efficiency can be derived from this alone.

There are jobs, however, which are impractical to do; one is rewinding electric motors, which is becoming a thing of the past in most plants today. When a motor must be rewound it can be done cheaper in a contract shop, with present high speed multiple type winding coil machines, and men trained for the job.

The following is a brief outline, that has proven to be a good formula for low cost electrical maintenance—periodic checking of motor bearings with feeler gages, cleaning with compressed air and vacuum cleaners. The motors under certain conditions should be taken apart, cleaned with non-inflammable cleaning fluid and then sprayed with a good grade air dry varnish. A well designed motor should be selected, with thermal overload protection on all starting switches.

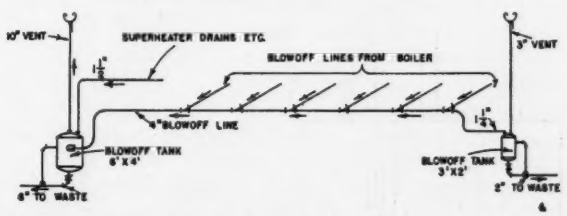
The plant engineer is to a large extent responsible for the welfare of the employees. His efforts can do much to create a feeling of good will. Their health should be guarded by a periodic testing of drinking water and a good air conditioning system must be maintained. He is on the lookout for good safety methods, labor-saving devices, good lighting and general cleanliness of the plant.

The plant engineer must always be alert to new developments in equipment and processes. Through the co-operation of the management, he should be given an opportunity to visit other plants, attend engineering meetings and get a broader view on his own problems. This does not mean that consulting engineers and men that are specialists in their line should not be called in when the occasion arises. The savings resulting from hiring professional engineers make their fees appear insignificant. The problems solved by the plant engineer will be the answer of our success in the future.

Rockford, Ill. NELS W. OMAN.

Auxiliary Blowoff Tank Eliminates Piping Troubles

WHERE the blowoff lines from a number of boilers enter a single discharge header, a number of operating and maintenance troubles are often encountered. Perhaps the most frequent source of these difficulties is the tremendous strain on piping and fittings caused by both water hammer and by the intermittent expansion and contraction, incidental to the sudden release of hot, high velocity water when boilers are blown down. These forces are often responsible for the rupturing of various parts of the system or the breaking away of its anchorage points.



Small blowoff tank connected to the header and farthest from the main blowoff tank

Another common difficulty is the stopping up of the blowoff line by suspended material in the blowoff water. While this condition is not generally experienced with all boilers in service, any dead end in the line caused by one or more boilers at its extreme end being out of service usually chokes up with mud deposited by back wash when active boiler blowdown valves are operated.

In one large boiler installation a small blowoff tank connected to the header end farthest away from the main blowoff tank by a 1¼-in. line eliminated most of the troubles enumerated above. As shown in the sketch, this tank provides a means of relieving any back wash that might cause dirt deposits or destructive water hammer.

Roanoke, Va. S. H. COLEMAN.

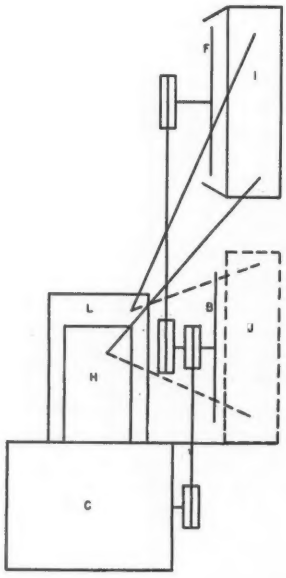
Equipment Shift Boosts Compressor Output

DRIVEN at 10 per cent overspeed to try to meet the plant's air needs, the two-stage compressor still failed to deliver its rated output even though carefully checked and found mechanically in order. Noting that the blast from the fan, located at J, and provided for drawing air through the fins of the intercooler, was uncomfortably hot even before it passed over the cooling fins of the compressor cylinders, temperature observations were made. It was found that the cylinders were adding almost no heat to the blast of air.

To avoid this condition, the intercooler was raised vertically from its former position and supported on a welded pipe rack at a height which would allow the blast of air drawn through it to pass completely above the compressor unit. To provide cooling air for the compressor, a two-blade airplane type fan was mounted on the original fan shaft, and covered with a wire mesh guard as safety precaution. Drive for the intercooler fan was obtained by mounting a second pulley on the blower fan shaft, with V-belt drive to the upper fan.

Although calculations showed that an increase in air output of not to exceed seven per cent could be expected from the intercooler shift, tests proved that the gain was 15 per cent or better. The additional gain was ascribed to more effective compression seal by the lubricant used at the lower operating temperatures obtained with bettered cooling.

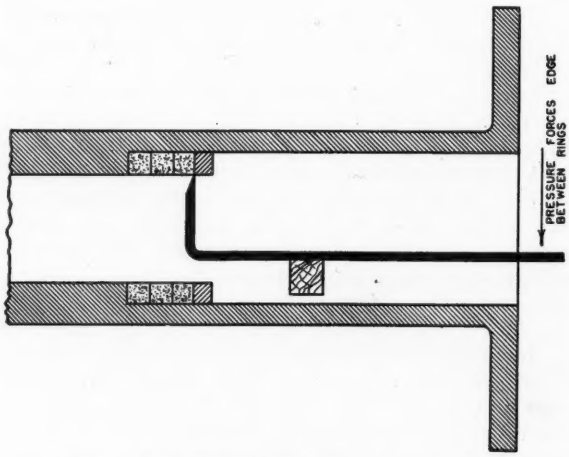
Longview, Tex. ELTON STERRETT.



Plan of the compressor unit showing the old and new cooling arrangement. C, compressor. L and H, low and high pressure cylinder. F, new fan location. B, original intercooler location. I, new intercooler location. J, original intercooler location

Removal of Valve Packing

SEATLESS bottom blowoff valves frequently become obstinate when the time comes for re-packing the plug. Obviously, the bottom blow occupies the most favorable place on a boiler for the accumulation of sludge, scale and solidified boiler compound, and the valve is not used often enough to keep the deposits moving with the result that the packing rings become solidly set in a mineral cement which makes removal of the packing a difficult and fussy affair. It is impossible to see the job and work on it at the same time which establishes a pick-and-peek situation lasting an hour or two for a job which should take only a few minutes.



Method of removing packing rings from seatless bottom blowoff valves

A lot of nervous wear and tear can be eliminated and much time saved by use of the familiar file-scraper. Grind the scraper to a knife edge, as shown by the sketch, and then slide it through the barrel of the valve until the point can be felt entering the joint between two rings. A block of wood or any other convenient small object can be used as a fulcrum to force the points between the rings, and a sharp pull on the scraper will flip the ring out of the body of the valve in one piece. Repeating the process for each ring requires only a few minutes, and the barrel is left clean and ready for the insertion of new packing.

In the sketch a metallic follower is shown on top of the packing although this usually comes out easily. The same method, however, applies in case it sticks. The job can be done entirely by the sense of touch and affords no possibility of damaging the valve, which can not be said of a hammer and chisel in the hands of an exasperated operator.

Alameda, Cal. P. F. CHRISTOPHER.

Forced Draft

J. R. DARNELL suggests that power plant operators would do well to gain a thorough knowledge of the fundamental principles governing the operation of mechanical draft fans, particularly those for forced draft with underfeed stokers.

That is a good idea, it would add to our store of knowledge; but operating engineers are so imbued with confidence in the designing engineers that, when they take charge of an underfeed stoker job, they are sure that the boilers can be driven to 200 per cent rating if necessity so demands.

Some years ago a boiler of a set of three was driven to find its ultimate capacity. When the test was over and the boiler shut down the furnace lining looked like molasses had been poured from the top and stuck to the walls in uneven layers. The furnace lining had to be repaired, but the stoker and draft fan showed no sign of weakness after the cruel treatment to this fine set of equipment.

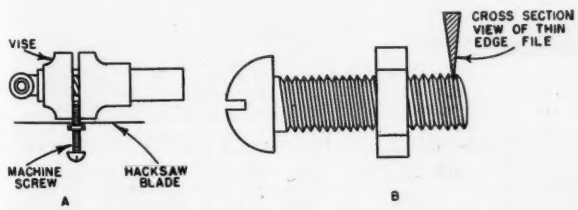
Another forced draft fan was sold 12 yr. ago and during the past 12 yr. it has only got such attention as oil in its bearings, but no repair to any of its parts. The driver and horizontal steam engine naturally have demanded its care due to the joints that need attention.

When we consider the ruggedness displayed by this type of equipment it is logical to assume that the operating engineers can safely depend on the designing engineers and devote their mental energy to make the fan move the gases over the heating surface so that when they enter the uptake the temperature is reduced to a little above that of the steam in the boiler, and at the same time keep a CO_2 percentage of about 14. Then we know that the number of pounds of water evaporated per pound of coal has reached a desirable goal and all will tip their hats to the designing engineers and give them all the glory.

Philadelphia, Pa. B. HJORTH.

Machine Screws and Bolts

AT TIMES it may be found that a needed size of machine screw or bolt is not conveniently available in the correct length. If one of the correct diameter and number of threads is on hand, it may be cut to the desired length. The following method is suggested: Screw a nut on the screw or bolt past the point where you wish to cut it. Then clamp the end of the screw or bolt in a vise and cut through with a hacksaw, as shown at A. Next, smooth and slightly round the end on a grinding wheel. Afterwards, smooth up the threads at the end by means of a thin edged file as shown at B. Then screw the nut off of the screw or bolt and screw it on again to determine whether the threads are satisfactory.



Steps in shortening machine screw

Baltimore, Md. THOMAS TRAIL.

Don't Be Afraid to Upset Your Power Plant System

AN EXCEPTIONALLY interesting lesson for power plant engineers recently came to this writer's attention regarding a prominent manufacturer of dry ice. This dry ice maker, years ago, developed a method whereby he obtained "perfect balance" in the operation of his plant. "Just enough" fuel was burned to give him the exact amount of carbon dioxide needed. This fuel, also, was "just enough" to generate the amount of power that was needed and the amount of steam required for distilling and removing the carbon dioxide out of his stack gases, compressing it, and in addition for reactivating the agent used for purification. He thought his installation was the "last word."

Years rolled by. His boilers, compressors, and other equipment became badly worn and from time to time he found it necessary to install new equipment—and, naturally, he installed equipment that was "modern."

But the initial results were not exactly what he wanted. The more efficient boilers generated more steam per pound of coal than the old ones did, of course, and the compressors compressed more gas per horsepower. As a consequence he found that his system was thrown out of balance. The one-horse-shay idea with which he started no longer held. His boilers were so efficient that there wasn't enough carbon dioxide in the stack gases to supply his needs, and his engine was so efficient that it didn't provide enough exhaust steam for the necessary reactivating. The only way in which he could get around the exhaust deficiency was to use live steam out of the boilers to make up for the exhaust steam that was lacking.

He was in somewhat of a quandary for a while—until a chemical concern showed him how his problem could be solved by means of a new process which they had developed.

So the new chemical equipment was installed, in addition to the new power plant equipment, and now the plant is in perfect balance again. And, more important, he is now getting much more carbon dioxide out of the plant per pound of fuel than he obtained before. In round numbers he is now producing 2½ lb. of carbon dioxide per pound of fuel instead of the 1 lb. of CO_2 per pound of fuel previously produced. And, what is more, only 5 per cent of the carbon initially contained in the fuel is lost, which means that 95 per cent of the carbon is converted into dry ice, which is doing very well indeed.

The moral is: don't be afraid to upset your present system by installing equipment that is more efficient. In the end you will very likely benefit.

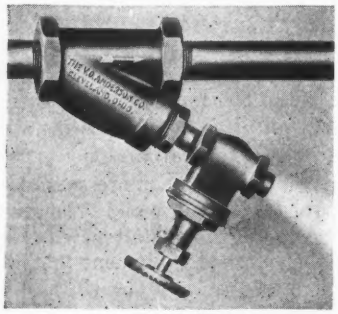
Newark, N. J. N. G. NEER.

New Equipment

Information that you desire about any equipment will be gladly furnished without obligation. WRITE POWER PLANT ENGINEERING.

Strainer

THE V. D. ANDERSON Co., 1935 West 96th St., Cleveland, Ohio, announces a new self-cleaning strainer with stainless elements. Body of the strainer is made of alloy cast iron suitable for maximum steam operating pressures of 250 lb. and

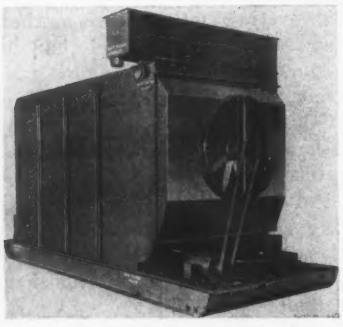


a maximum temperature of 450 deg. F. The strainer elements are standard equipment and have an extremely large free area. The strainer cleans itself when a blow-down valve is used or when pipe plug is removed.

Portable Engine-Cooling Units

WATER cooling of 100 to 400 hp. engines, which must be occasionally or frequently removed to new locations, as in oil fields, lumber camps, etc., has been successfully and economically accomplished only in recent years. Having pioneered in the building of portable mechanical-draft units, The Marley Co., Kansas City, Kansas, now offers a perfected line of four standard models designed to meet the many problems of this type of service.

Inside a closed system of copper atmospheric tube sections, soft engine jacket water is cooled without exposing it to outside air. The tubes are externally cooled by any kind of raw water which may be most cheaply available to the location. Thus the valuable soft water is saved for continuous recirculation and kept pure, preventing internal scale which cracks cylinder heads and often results in prolonged costly shut-downs.



Simple hook-up eliminates costly new arrangements and piping at each move. One man and a truck with a power winch can pick up, transport and unload any of the four models. Compact and sturdily built for heavy-duty service, they withstand rough handling in transit and severe use and exposure on the job.

Draft through the unit is induced by a quiet Marley fan so that cooling efficiency is independent of natural air movement. A single power unit drives both the fan and the centrifugal pump for circulating the raw water. This power unit may be an a.c. or d.c. electric motor, gas or gasoline engine, any or all of which are available with the unit. Adaptable mountings permit the swift removal of one type of power unit and the hook-up of another.

Double Offset Boxocket Wrenches

TOOLS that will simplify many nut turning jobs in maintenance or production work are the latest design of double end Boxocket wrenches manufactured by Snap-on Tools Corp., of Kenosha, Wis. Each tool gives two different wrench openings, and all sizes from $\frac{7}{16}$ to $1\frac{5}{8}$ in. are included within the range of this series.

Boxocket wrenches provide a maximum amount of safety on any nut turning operation. The wrench head grips the nut on all sides and distributes the pulling strain evenly around the nut. They can be used over long threaded bolts on which socket wrenches cannot be used or in small clearance spaces above the bolt, double broaching of the head permits their use in close places where handle movement is very limited.

The offset head allows the wrench to be used over obstructions, also provides clearance space for the mechanic's fingers, and the long handles on these wrenches provide for plenty of leverage for loosening tough nuts or for pulling them up extremely tight.

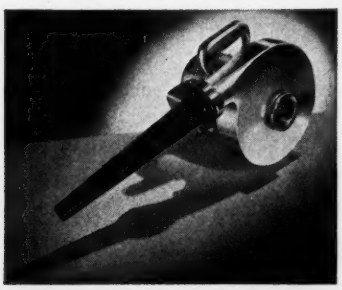
Floor Patching Material

FLEXROCK Co., 2301 Manning St., Philadelphia, Pa., announces the improved ruggedwear resurfacer. This product has been in existence for 5 yr. and has just undergone its second improvement. The first improvement was the cellulose

process which made the product tough and simplified the process of application. Addition of montmorillonite, which is chemically composed of manganese, silica, alumina and iron, is the second improvement. This addition makes it mix easier with cement, sand and stone and also increases the coverage capacity per pound of resurfacer.

Portable Blower

DEVELOPED by Cadillac, this new Model HP Blower is manufactured by the Clements Mfg. Co., 6650 South Narragansett Ave., Chicago, Ill. It has the following features: high and low speed,



sturdy, sand cast aluminum housing, single cast aluminum pan, statically and dynamically balanced, 3-cord heavy duty cable for positive grounding and low torque on starting from low speed switch.

Photo News Valve values

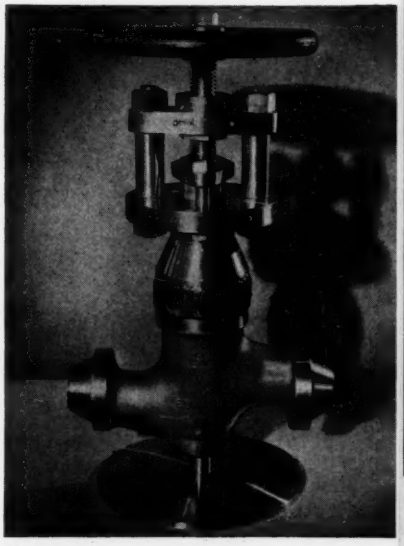
THE EDWARD VALVE & MFG. CO., INC. • EAST CHICAGO, INDIANA

EDWARD VALVES KEEP PACE WITH THE NEWS!

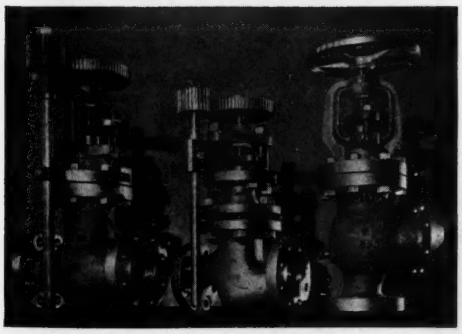
FOR AMERICA'S NEW MERCHANT MARINE, FOR THE STREAMLINERS OF THE GREAT WEST, FOR SUPER-POWER CENTRAL STATIONS, HIGH EFFICIENCY INDUSTRIAL BOILER HOUSES OR ULTRA-PRODUCTIVE REFINERY PROCESSES, EDWARD CAST OR FORGED STEEL VALVES KEEP IN STEP WITH THE TIMES. SOUND IN FUNCTIONAL DESIGN, THEY ARE EASILY ADAPTED TO HARD JOBS.

One thing all Edward valves have — basic fitness for tough service. Edward experience in high pressure and high temperature installations, accumulated through the years, provides a reliable background for steady, continuous progress. It is Edward engineering policy to go places — but without undue risk.

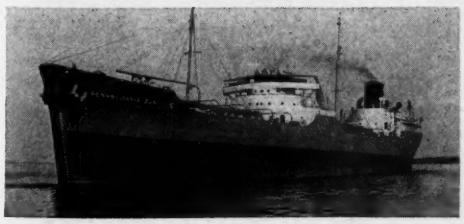
SEALED BONNET COMING? Welded joints in pipe lines have contributed to the peace of mind of boiler house operating men. Welding applications have gone much farther than boiler lines. They also are used extensively in refinery service, in cross country pipe lines and even on oil well casings. Naturally, therefore, operators ask why valves still need bolted bonnets. Answer is that foreign matter gets into pipe lines and too often causes troubles which necessitate the disassembly of the valves. Picture shows an Edward 1500 lb globe stop valve with Stellited seat and disk. The seat is welded in place in the body. Question is how to keep tramp metal out of lines.



5,000 hp. LOCOMOTIVE. New steam-electric unit, developed by General Electric and Union Pacific, for speeds to 125 mph, uses Edward valves. Boiler pressure 1500 lb at 920 F.

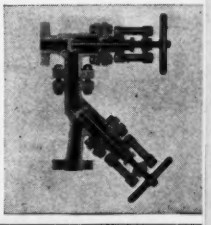


PEACE TIME HIGH. With contracts let for 51 new vessels U. S. Maritime Commission has brought shipbuilding activities to a peace time record. Edward valves are to be used on a majority of all vessels under construction, both motor and steam ships. Cut shows Edward marine valves—gear operated stop check, angle stop, cast and forged steel.

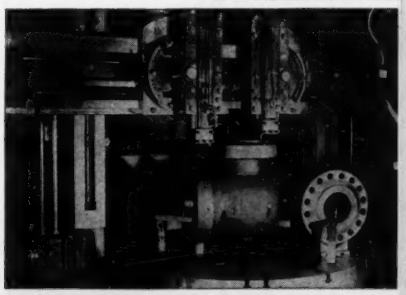


TANKERS USE EDWARD VALVES. Sensational progress in past few years in building high efficiency oil tankers has brought important additions to American shipping. This motorship uses a waste heat boiler.

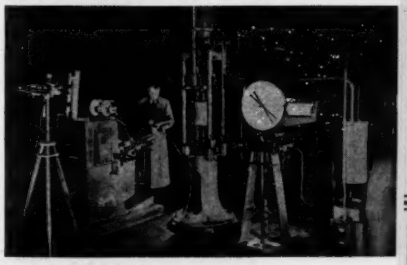
FORGED BLOW-OFFS. For all boiler pressures over 320 lb — for land service — Edward offers forged steel blow-off valves. Marine ratings are lower. For long continued operation at high pressures, without emergency shutdown, the disk type of blow-off valve has been found indispensable. Cross sectional view shows one of a number of optional arrangements of Edward blow-off valves in tandem. Seat and disk EValloy or Stellited.



BIG VALVE FOR TEXAS. Boring mill shown at right has 102 in. swing, but elbow inlet body casting, which is being machined, barely cleared the frame. This is a 12 in. 1500 lb sp non-return valve. Body and bonnet of nickel-chromium-molybdenum alloy cast steel.



SWISS TENSILE MACHINE. Getting the correct answer is the task of this formidable piece of Edward laboratory equipment, built to order in Amsler works at Schaffhouse. Results depend on extreme accuracy of temperature control, measurements of strain, and expert technique.



EDWARD VALVES

Stop · Check · Blow-off · Non-return · Feed Line · Relief · Bleeder Line · etc.

Construction and Engineering Prints

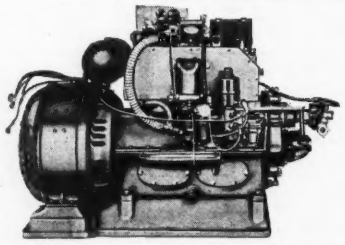
FOR CONSTRUCTION purposes, black lines on a white background are clearer than blueprints, and have the advantage that ink changes or additions can be readily made on the print. In the Ozalid method, positive (black on white) prints can be made in one operation; also, by making transparent duplicates of drawings that cannot be altered, changes may be made by removing unwanted lines by a chemical deletion and alterations drawn in. In the Ozalid white print machine, the white print is made by exposure to light, same as a blueprint, but the positive, black on white, is obtained

and is developed dry by exposure to dry ammonia fumes, no liquids being used and no drying needed. Those having blueprinting equipment can use that for the exposure, and a separate Ozalid developer may be purchased. In the automatic machine, however, original and sensitized sheets are passed under a rotating glass cylinder, the sensitized sheet then going through the developing chamber and being returned to the operator at the front of the machine, dry, without wrinkling or change in dimensions and ready for use. Cut sheets of any desired size may be used, requiring no after trimming. Sizes are built to take sheets from 36 up to 54 in. wide and with speeds from 18 up to 50 linear in. per min. Units are compact and cost of operation has been found by users to be low. The equipment and sensitized paper is made by Ozalid Corp., 354 Fourth Ave., New York, N. Y.

Automatic Fuel Selector

JUST announced by the Universal Motor Co., Oshkosh, Wis., Automatic Fuel Selector, composed of three principal parts, a temperature switch, a three-way solenoid valve, and a time delay relay, makes the operation of fuel oil electric plants as simple as burning gasoline. Owing to the fact that fuel oils do not vaporize thoroughly for proper combustion except at certain high temperatures, it is customary to start fuel oil burning engines on gasoline. After running on gasoline from 3 to 5 min. it is then switched over to fuel oil. Before stopping the engine, the carburetor fuel line must be cleared of fuel oil and primed with gasoline for the next start by switching over to gasoline for 2 or 3 min. before stopping. These operations are usually done manually but with this Automatic Fuel Selector they can be done automatically and the problem of starting and stopping on gasoline can be forgotten as far as the operator is concerned.

When the starter button is pressed, the motor starts and runs on gasoline until the temperature reaches 130 deg. F. At this point the contact in the temperature switch closes and the coil in the solenoid valve becomes energized, closing the gasoline port and opening the fuel oil port to the carburetor. The

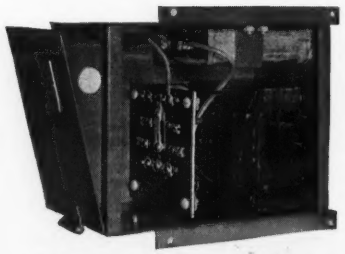


motor then runs on fuel oil. When the ignition switch is cut off, the coil in the solenoid valve becomes deenergized, opening the gasoline port and closing the fuel oil port to the mechanism. The time delay relay then allows the motor to run about one to one and a half minutes, just long enough to clear the mechanism of fuel oil before it closes, opening the coil circuit which stops the motor. The motor is then ready and primed with gasoline for the next start. By means of a convenient emergency switch, the motor can be stopped immediately at any time necessary.

Speed Controller for A.C. Motors

ILLUSTRATED is a Raytheon multi-step speed controller for a.c. motors which makes it possible to vary the motor speed by changing the input voltage. This method of speed control permits the motor being operated by a thermostat or automatic switch because it definitely insures that the motor will always restart, regardless of the controller setting.

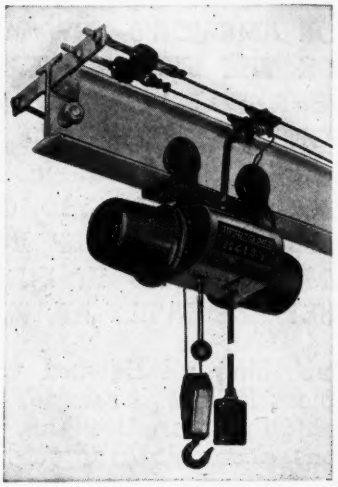
A typical controller is illustrated, showing its principal components, an autotransformer with voltage adjustment taps and an oil-filled condenser. There are no moving parts and nothing to wear out.



Raytheon speed controllers are custom built to exactly suit the motors and, therefore, are sold only in quantity. The method of mounting is selected to meet the customer's needs, for wall mounting, for mounting within a ventilated cabinet, or for mounting on the motor itself. Any desired method of voltage control can be furnished—for example—a movable link, as shown, or an enclosed multiposition tap switch. Raytheon Mfg. Co., Willow St., Waltham, Mass.

Wire Rope Electric Hoist

AMONG the recent developments in hoisting equipment is the Speedway, a light weight low cost wire rope electric hoist, with hoisting capacities ranging from 250 to 750 lb. and hoisting speeds 15 to 43 f.p.m. The Wright Speedway electric hoist standard construction in-



cludes fully enclosed ball bearing motor, anti-friction bearings, cut alloy steel spur gears, multiple disc solenoid brake, push button control, preformed hoisting cable and many other quality features which make it suitable for production service. This hoist is made in three types for lug suspension, hook suspension or mounted on trolley. Wright Manufacturing Division of the American Chain & Cable Co., Inc., York, Pa.

Graphite Lubrication

USE of colloidal graphite suspended in water to provide long life lubrication for small mechanical devices, difficult to lubricate by conventional methods, was discussed on page 86 of the January issue. For some services the solution is made with oil instead of water and it was stated that this was a "disadvantage". Obviously this was meant to be "advantage" for a graphited surface has the ability to hold oil and thus insure the maintenance of an oil film under severe as well as light service conditions. The "apparent disadvantage" of the oil solution as used in the original article referred to special cases where some form of lubrication is necessary but an oily surface is undesirable, either in itself or because temperature conditions are such that the oil will burn off leaving an undesirable residue.

Another new product has been developed by the Acheson Colloids Corp., Port Huron, Mich., to take care of these cases. For instance, conveyor chains operating in high temperature zones, such as in baking and enameling ovens. Common lubricants cannot be used since they would burn off and the solution of the problem was found through the development of a new form of colloidal graphite, so finely divided that it can be suspended in suitable volatile liquids. The liquid, kerosene in this case, merely evaporates, leaving a very thin deposit of fine colloidal graphite on the surface.

WHICH DO YOU USE—

Internal or External Feedwater Treatment?

READ THESE REPORTS

PLANT A Uses continuous feed internal treatment under Nalco supervision with 80% raw make-up. Operating pressure is 225 lbs. with ratings up to 300%. Runs boilers five months or more between washings. No scale requiring removal at inspections.

PLANT B Uses hot process softener and after-treatment under Nalco supervision with 100% make-up. Water sometimes carries as much as 12 grains soluble silica. Ratings run as high as 300 or 400%. One boiler recently completed 11 months on line and was still clean when shut down to erect new stack.

PLANT C Uses internal treatment prescribed by Nalco laboratory. 400 lbs. operating pressure. Boilers run six years without turbining tubes. The customer writes "we are very well pleased with the results."

YOU may have thought that with your particular facilities for conditioning boiler feedwater no completely satisfactory results could be maintained. That's why we asked you to read about the cases described here.

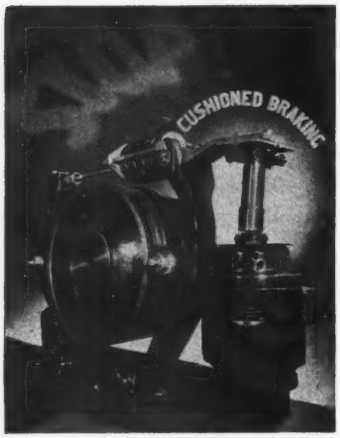
Nalco engineers specialize in adapting the Nalco System to fit your plant rather than requiring you to change your plant to fit a set method. As a result, you get a real solution for your problems at minimum cost. A Nalco survey will give you the facts. *Write for information.* NATIONAL ALUMINATE CORPORATION, 6224 W. 66th Place, Chicago, Illinois.

ANY WATER **NALCO SYSTEM** ANY PRESSURE

Inquiries other than domestic, *except those from U. S. Possessions, Canada and Mexico*, should be addressed to ALFLOC LTD., Bush House, Aldwych, London, W. C. 2, Eng. Canadian inquiries should be sent to ALUMINATE CHEMICALS LTD., 372 Bay St., Toronto, Ont.

A. C. Torque Motor Operated Brake

DESIGNED especially for those applications where positive, quick, cushioned braking is required for stopping or holding a load, a new torque motor operated brake for alternating current service on elevators, cranes, hoists, and similar installations is announced by Cutler-Hammer, Inc., 295 North 12th St., Milwaukee, Wis.



Operating through a simple anti-friction ball jack motor releases the brake. When the brake is fully released, the torque motor is stalled across the line. When the circuit is opened, the heavy, helical torque spring sets the brake. A slight flywheel action of the rotor provides smooth, cushioned braking. Available in five sizes, this brake provides maximum torque ratings of 160, 400, 800, 1600 and 3200 lb. ft. on intermittent duty. Continuous duty ratings are slightly lower. Available for all commercial frequencies and voltages.

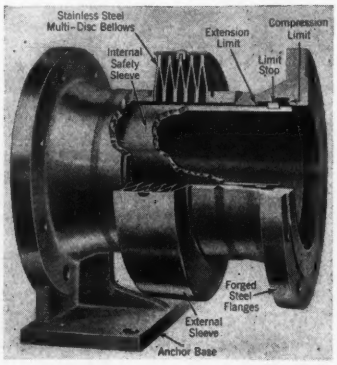
Continuous Blowdown Valve

SEATS and discs having almost diamond surface hardness are featured in a continuous blowdown valve announced by The Strong, Carlisle & Hammond Co., Cleveland, O. Hardness of the Anum-Metl "X" seat and disc available in the continuous blowdown valve has been achieved without sacrificing toughness. The Strong Volumetering assembly in-

creases the accuracy of blowdown control as well as lengthening valve life. This assembly consists of the valve plus a fixed Anum-Metl orifice. After passing through the valve, blowdown volume is greatly increased and the pressure is reduced before it passes through the fixed orifice. A pressure gage between the valve and orifice allows visual and accurate control of blowdown.

Expansion Joint

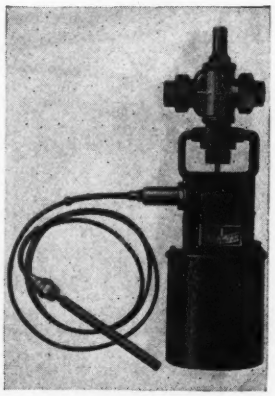
FOSTER WHEELER CORP., 165 Broadway, New York., announces an all-welded, all-steel, packless expansion joint, made in standard pressure series of 50, 150 and 300 lb. per sq. in. and sizes from 2 to 36 in. inclusive. The regular construction is good for temperatures to 750 deg. F. The flexible element in this



joint consists of a stainless steel bellows, fabricated under the exclusive "STA-NORM" electric welding process. This joint is the highly refined type S, involves no adjustments or lubrication by the operator, and is a single welded construction from end to end. Materials are of forged and rolled steel specially selected and fabricated for the services involved.

Temperature Regulator

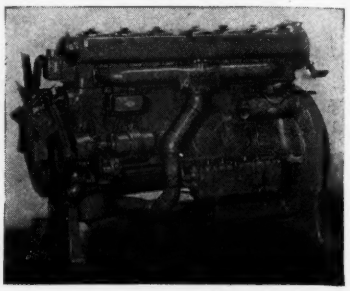
THE NEW self-contained electric temperature regulator just announced by the Sarco Co., Inc., 183 Madison Ave., New York, N. Y., is suitable for temperatures between –40 deg. F. and +650 deg. F. Operation is by single phase alternating current, 110 or 220 v. 60 cycles.



Current consumption is less than 50 w. and no relays are required. The valve is of the throttling type and will adjust itself automatically to any position between wide open and closed. Standard valves ½ in. to 2 in. inclusive have bronze bodies, stainless steel trimmed and union connection. Valves 2½ in. to 4 in. are iron body, bronze trimmed.

Diesel Engine

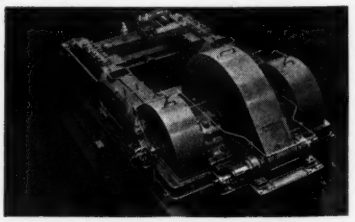
THE MURPHY DIESEL CO., LTD., of Milwaukee, Wis., announces a new 200-hp. Diesel engine, known as ME-650. The design of this engine conforms to that of the standard Murphy Diesel Model ME. Injection is direct into a plain symmetrical combustion chamber. Injector and fuel pump are combined in one unit which is easily and quickly removed and replaced. There are no high pressure fuel lines and injectors cannot become air bound.



Four valves are provided for each cylinder, assuring maximum breathing capacity and rapid scavenging. Should the oil pressure drop below a fixed minimum pressure, the engine automatically shuts itself off. Control is through a single lever which permits easy and simple toggling-in for remote control. Starting is accomplished by a standard 24 v. starter.

Synchronized Control for Reciprocating Pumps

FOR AUTOMATIC delivery control of high pressure reciprocating pumps, a synchronized unloading and loading device has been developed by Worthington Pump and Machinery Corp., Harrison, N. J. Suction valve controlled, air actuated, the new mechanism guarantees a quick but gradual decelerating fluid delivery from full flow to zero, and vice-versa. In either case the action is the



same. The time required for fully unloading or loading any type of multiple plunger reciprocating pump, horizontal or vertical, duplex, triplex or otherwise, does not exceed one-half of one revolution of the pump.

It provides positive synchronization of action in loading and unloading, regardless of the point in the pump revolution at which the control functions. The individual cylinders load and unload in sequence on the suction stroke, the action starting with any cylinder, with consequent elimination of shock.

LUNKENHEIMER
BRONZE GATE VALVES

A Complete Line
for Steam, Water, Air, Gasoline and Oil Service

Fig. 2125
¼ to 3 in.
125 lb. S.P.
200 lb. W.O.G.

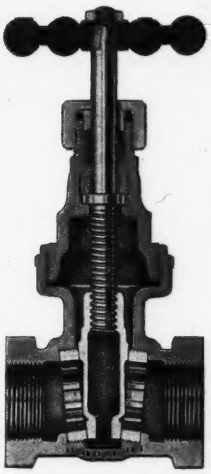


Fig. 768*
¼ to 3 in.
200 lb. S.P..
400 lb. W.O.G.

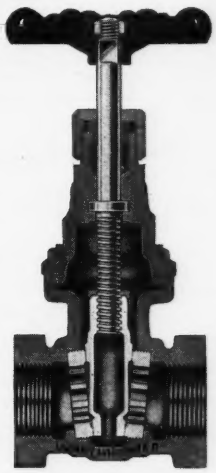


Fig. 771*
¼ to 3 in.
300 lb. S.P.
600 lb. W.O.G.

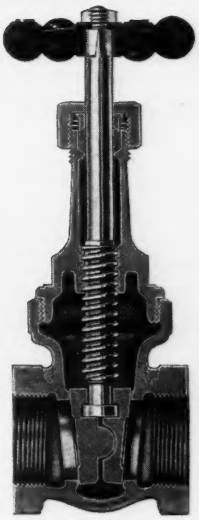


Fig. 427
¼ to 3 in.
150 lb. S.P.
300 lb. W.O.G.

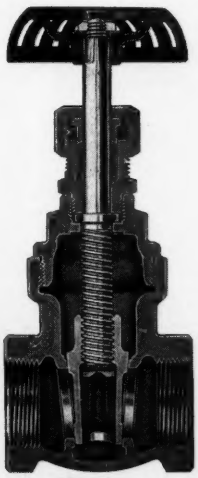


Fig. 2129
¼ to 3 in.
125 lb. S.P.
200 lb. W.O.G.

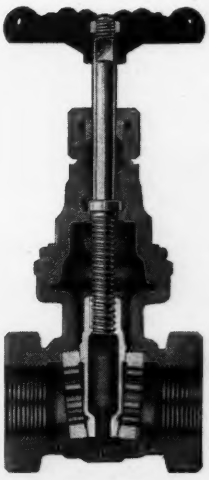


Fig. 1881*
¼ to 2 in.
350 lb. S.P.
1000 lb. W.O.G.

*Figs. 768, 771 and 1881 have renewable nickel alloy seat rings 1 in. and larger.

All patterns illustrated are also available with flanged ends.

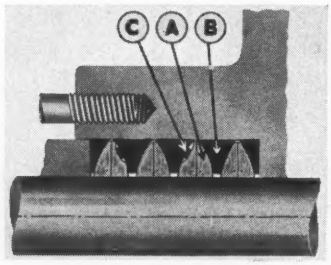
ESTABLISHED 1862
THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI, OHIO, U. S. A.
NEW YORK CHICAGO
BOSTON PHILADELPHIA
EXPORT DEPT 318-322 HUDSON ST., NEW YORK

BOILER MOUNTINGS — LUNKENHEIMER VALVES — LUBRICATING DEVICES

11012-47A-44

Neoprene and Metal Packing

DESIGNED to give long, service regardless of the severity of the job which must be done, this packing, manufactured by Rodpak Mfg. Co., San Francisco, Cal., employs two metal rings, A, (convex on one face and flat on the other) as the sealing medium on the shaft. For some applications these rings are made of a special babbitt metal, while for others a metal which will resist heat up to 700 deg. F. is employed. Between these sets of rings are rings of neoprene B which are concave on both faces so that they will mate with the convex faces of the metal rings.



Beryllium copper springs, C, are embedded in the rubber or neoprene rings. These springs seat themselves in recesses provided for them in the metal rings and have a twofold purpose. When the packing is in use on centrifugal units, they prevent it from turning with the rod. When the packing is used on reciprocating rods, the springs are so placed that they exert an inward and downward pressure to offset any irregularity of the rod. The springs also compensate for low follower heads, up-and-down motion or side sway.

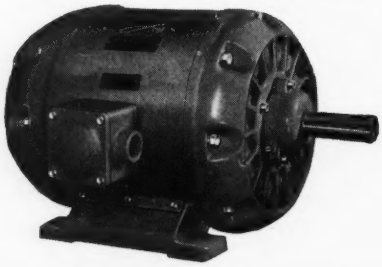
This construction provides a floating seal under all conditions. The metal rings seal the rod but do not touch the stuffing box. The neoprene rings seal the stuffing box but do not touch the rod. As only the metal rings touch the rod, the coefficient of friction is very low.

Paracoil 3-way Swing Valves

PARACOIL 3-way swing valves made by Davis Engineering Corp., Elizabeth, N. J., are an essential and integral part of a modern waste heat recovery system and accurately regulate the quantity of heat to the waste heat boiler to conform with the frequent variable load periods. Moreover, these valves permit a complete by-passing of the exhaust gases. They are of the swing type with gear operating mechanism to permit of an easy and quick self locking adjustment to suit the requirements of boiler output. The large internal areas are in excess of pipe size so as to assure an unrestricted flow of gas. Furthermore, these valves close tightly without jamming or freezing shut. No two outlets can be closed simultaneously to cause the engine to exhaust against a closed line.

Explosion Proof Motor

THE LOUIS ALLIS CO., Milwaukee, Wis. have developed a new streamlined explosion proof motor which is said to incorporate 18 separate and distinct major mechanical and electrical improvements. This motor, illustrated herewith is described in a new booklet No. 508 E which will be sent on request.

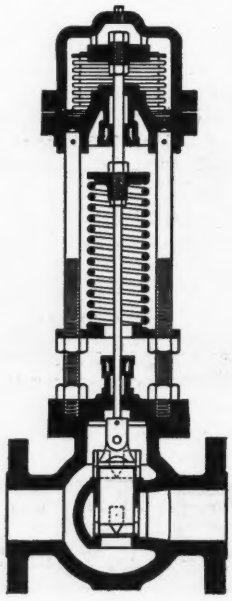


Pump Governor

NORTHERN EQUIPMENT CO., Erie, Pa., announces a new pump governor, the Copes Type SL, designed especially for service on steam-driven reciprocating pumps or on centrifugal pumps driven by small steam turbines. It is suited for excess pressure service in boiler feeding where the maximum excess pressure is no more than 75 lb. per sq. in. It may also be used for constant-pressure service, where the controlled pressure is not to exceed 75 lb. It is furnished in sizes from ¾ to 3 in., in the 250 lb. and 300 lb. pressure standards only.

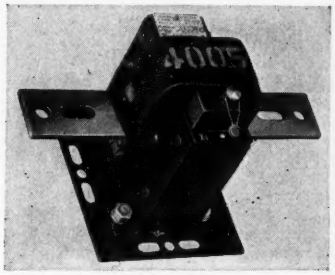
The actuating element, a 4-ply brass sylphon bellows, is protected against water hammer or sudden changes in pressure by a stabilizer.

This governor is spring-loaded. The spring is carefully selected to have exactly correct characteristics for the specified pressure conditions, so that the pressure control provided is dependably accurate. An accurately balanced bevel-seating valve piston gives added assurance of instantaneous response to pressure variations, so that control is accurate under all loads.



Indoor Current Transformer

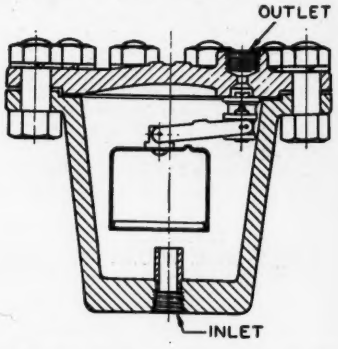
A NEW INDOOR current transformer designed to combine the advantages of small size with high accuracy for metering on low voltage circuits has been introduced by General Electric. Designated Type JL-1, it is rated 600 v. and is offered in three current ratings: 200/5, 400/5, and 600/5 amp.

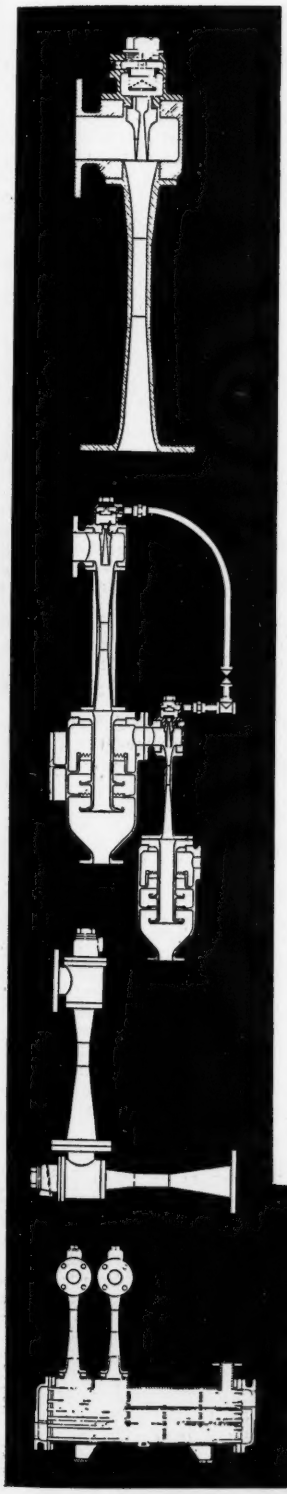


Primary windings of the JL-1 are of sufficient size to permit continuous operation at 150 per cent of rated primary current. Primary terminal surfaces are silver-plated, and the secondary terminals are the solderless type, easily operated with a screw driver. A removable mounting plate permits mounting the transformer on pipe.

Steam Trap

STEAM TRAPS of the inverted bucket type for pressures up to 900 lb. per sq. in. are now offered by Sarco Co., Inc., 183 Madison Ave., New York, N. Y. These new traps are suitable also for superheated steam of any commercial temperature. Body and cover are high grade steel forgings of a shape to give maximum strength. Special alloy steel bolts are used for attaching the cover to the body. All interior parts, including the bucket, are of stainless steel. A special, hardened stainless alloy is used for the renewable valve seat and disc.



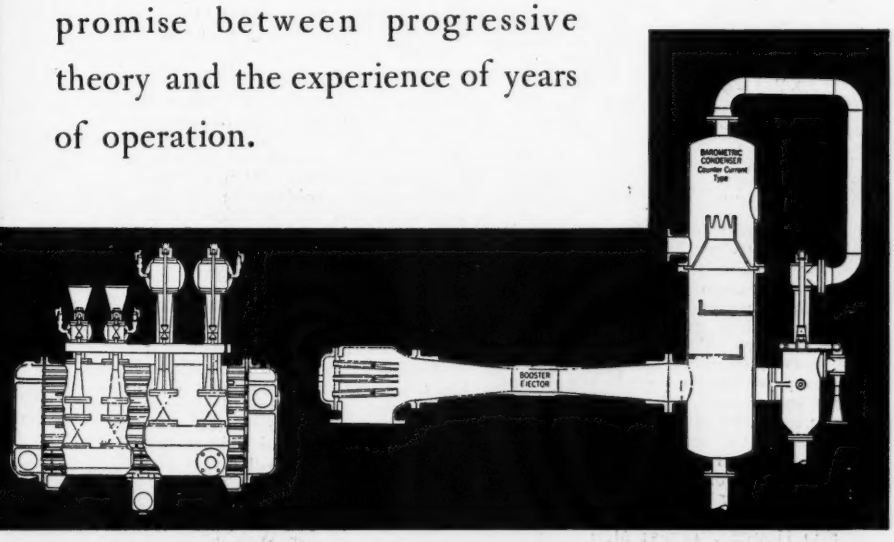


STEAM JET AIR EJECTORS

Whenever vacuum is a basic requirement of satisfactory operation—as in power plants and many manufacturing processes—high quality of the steam jet air ejectors is essential. Efficient operation, low maintenance, and maximum availability are reflected directly in higher output and lower cost.

Multi-stage, multi-element air ejectors by Foster Wheeler are constructed with surface, or jet, inter and after condensers; they are also equipped with isolating valves to provide greatest flexibility in operation and maintenance.

High quality in steam jets starts with experience—Foster Wheeler is one of the oldest manufacturers in the country. Design, materials and fabrication represent the most practical compromise between progressive theory and the experience of years of operation.



FOSTER WHEELER CORPORATION 165 Broadway, New York, N. Y.

FOSTER WHEELER

News from the Field

C. DONALD DALLAS, President of Revere Copper & Brass Inc., announced the appointment of Louis J. Galbreath as Technical Advisor for the New York District Sales Div., with headquarters at 75 East 45th Street, New York city.

Mr. Galbreath is a Cornell alumnus, having received his engineering degree in 1917 and during the war, served as ensign in the United States Navy. Prior to coming with Revere in 1935, Mr. Galbreath was account executive for Kenyon & Eckhardt, Advertising Agency of New York city and up to the time of his present appointment headed Revere's Product Development Department. The Revere Technical Advisory staff is headed, from a technical standpoint, by R. A. Wilkins, Vice President and Director of Research, and from the sales angle is directed by Chas. A. Macfie, Vice President and General Sales Manager.

ROBERT W. LEA, who has been president of the West Virginia Coal and Coke Co. has been elected a Vice President of Johns-Manville Corp. by the Board of Directors. Mr. Lea will be in charge of finance, and will take over the position formerly held by Enders M. Voorhees. He resigned as president of the West Virginia Coal and Coke Co. January 18, but will remain on the Board of Directors of that company. He will assume his new duties with Johns-Manville Corporation about the end of March.

GEORGE W. HAUCK has been made manager of the Engineering Sales Section of the Valve and Fitting Department of Crane Co. Mr. Hauck has been a member of the Crane organization since 1913.

REVERE COPPER & BRASS, INC., announces the appointment of Keith C. Bowers, formerly of the St. Louis office, as its sales representative in Western Missouri and Kansas with headquarters at 325 Ward Parkway, Kansas City, Mo.

W. H. JOHNSON, formerly purchasing agent of the Climax Engineering Co., Clinton, Iowa, has recently been appointed Purchasing Agent of Foote Bros. Gear and Machine Corp., Chicago.

D. W. HAERING & Co., Inc., announced removal of its production facilities to new and larger quarters at 2308 S. Winchester in Chicago. Alterations and installation of equipment in the two story factory building are to be completed about February 15. Production facilities and control laboratory are to be located in the new building while executive offices and research laboratories will be continued at 3408 Monroe St. in Chicago. Recent additions and promotions among the company personnel include the appointment of Donald C. Suhr, C.E., as district manager in the Detroit area; R. C. Rohrdanz, B.S., as resident engineer in Houston, Texas; M. Engolf as district manager in Minneapolis, Minn.; A. J. Haar as district manager in New York City; Ellis Pardee, B.S. to the laboratory staff in Wichita, Kansas, and Ralph Beardsley, B.S., and George Thompson, B.S., to the Chicago laboratory staff.

KENTUCKY COAL AGENCY, INC., a newly organized regional coal marketing agency, established its headquarters in Madisonville, Ky., on January 3, and will represent the producers of the western Kentucky coal field, which marketing organization recently was given provisional approval by the National Bituminous Coal Commission. Herbert C. Moore, formerly of the marketing division, Appalachian Coals, Inc., Cincinnati, O., is president of Kentucky Coal Agency, Inc., having been elected to that position by the board of directors on Dec. 15. Moore is the second Appalachian marketing man to head an agency similar to Appalachian Coals, Inc.

GENERAL CHARLES KELLER has been elected a member of the board of directors of Public Utility Eng. & Service Corp. to fill a vacancy caused by the resignation of Henry C. Cummins, recently elected vice president in charge of operation, Northern States Power Co., Minneapolis. General Keller, an honor graduate of the United States Military Academy in the class of 1890, has had a distinguished career in the Army and other government services. He has been identified with Public Utility Eng. & Service Corp. and its predecessor company since 1923 as an engineer on hydroelectric and other engineering projects.

AMERICAN CHAIN & CABLE CO., INC., announces the appointment of R. E. Greenwood as District Sales Manager of the Chicago territory of the American Chain Division, with headquarters at 400 West Madison Street, Chicago, Ill.,—succeeding G. B. Kutz who has been transferred to York, Pa., as Assistant to the General Manager of Sales, American Chain Division. R. C. Brenizer has been appointed Philadelphia District Sales Manager of the American Chain Division with headquarters at Second & Diamond Sts., Philadelphia, Pa.,—succeeding R. E. Greenwood, transferred to Chicago.

HEWITT RUBBER CORP., Buffalo, announces the promotion of James Martin from plant night superintendent to the position of assistant factory manager. His new duties will include the co-ordination of production, mechanical and technical problems in all factory divisions under the direction of E. K. Twombly, Vice President and Treasurer.

J. H. WILLIAMS & Co. has moved its New York office from 75 Spring St. a block distant to 225 Lafayette St., corner of Spring St.

NORTHERN EQUIPMENT CO., Erie, Pa., has announced the appointment of Harry H. Weining as in charge of all research projects concerned with the COPES System of Boiler Feed Control and allied equipment. He will report directly to V. V. Veenschoten, vice-president and chief engineer. Assisting Mr. Weining will be Francis W. Bunting and William E. Veenschoten. Mr. Weining joined the COPES organization in June, 1926, immediately following his graduation from Pennsylvania State College as a Bachelor of Science in Mechanical Engineering. Mr. Bunting, a Drexel Institute graduate, was associated with the RCA-Victor organization before joining Northern Equipment Company in August, 1935. Mr. Veenschoten has been with the company since shortly after his graduation from Pennsylvania State College in 1937.

ROLLER-SMITH CO., New York, N. Y., announces the appointment of W. R. Swoish as Sales Manager with headquarters at Bethlehem, Pa.

THE NEW YORK OFFICE of The Paul B. Huyette Co., Inc., has recently added to its sales engineers, Charles E. Harrington and Bruce H. Lemmon. These men will cover metropolitan New York and North Jersey for the company.

SIX DIESEL-electric streamlined trains will be placed in service this summer by the Southern Railway. They are being built by the St. Louis Car Co. and include 750 hp. Fairbanks-Morse Diesels each and Westinghouse electrical equipment. Each of the six motive power units will include an electric generator and two 450 hp. driving motors.

DURING the week beginning March 6th, the 1939 Regional Meeting of the A. S. T. M. and the A. S. T. M. Committee Week will be held at the Deshler-Wallick Hotel, Columbus, O. There will be some 150 meetings of standing committees and their subgroups as well as symposiums on thermal insulating materials and lime. On March 8 there will be an Open House at Ohio State University, featured by a general demonstration on Science and Engineering, arranged by the Ohio State Chapter of Sigma Xi in cooperation with Ohio State College of Medicine.

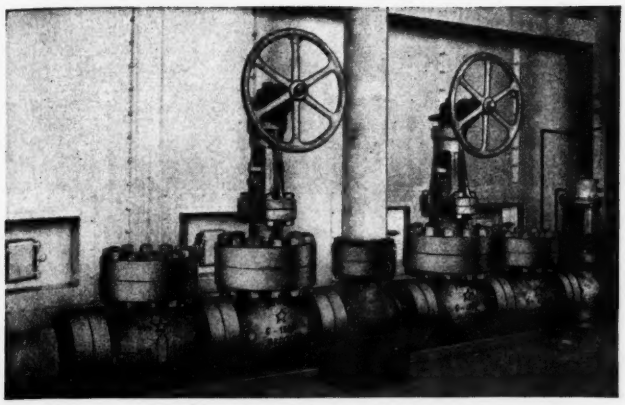
WILLIAM B. SCAIFE & SONS CO., Oakmont, Pa., has announced the appointment of L. A. Delaney as Mill Superintendent succeeding Charles E. Neudorfer, who has been appointed to the newly created position of Chief Engineer of the Mill. During the past five years Mr. Delaney has been Superintendent and Material Supervisor of the Baldwin-Southwark Corporation, a subsidiary of the Baldwin Locomotive Works. Other changes in the Scaife Company personnel include Eugene S. Sedlachek, formerly manager of the Water Purification Departments as General Sales Manager of ranges, boilers, special tanks, cylinders, domestic water softeners and domestic filters. Floyd E. Thelen succeeds John M. Green, who returns to the home office after serving 6 yr. as Manager of the Chicago Branch.

PITTSBURGH PIPING & EQUIPMENT CO., Pittsburgh, Pa., announces the appointment of Mr. C. H. Beckwith as district manager of their Chicago sales territory. After graduation from U. S. Naval Academy at Annapolis, Mr. Beckwith served in the Navy during the war. For the past 19 yr. he has been employed by the Crane Co. as a special representative. He has had extensive experience throughout the United States and in Canada and Mexico in the design, application and promotion of steam specialties. Mr. Beckwith will have offices in the Peoples Gas Bldg., Chicago, and the General Motors Bldg., Detroit.

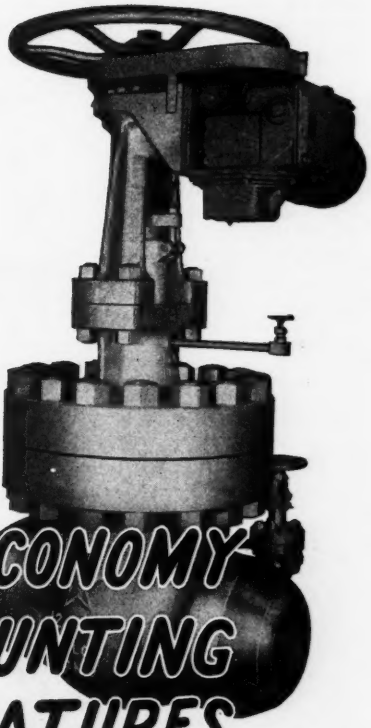
New Officers for Sullivan Machinery Co.

FREDERICK W. COPELAND has been announced as the new President of the Sullivan Machinery Co. Mr. Copeland has resigned the presidency of the H. Channon Co., Chicago, to take over his new duties.

Mr. Copeland was previously con-



1500 Pound Gate and Check Valve Installation



POWELL VALVE ECONOMY continues EVEN WITH MOUNTING PRESSURES AND TEMPERATURES

For 1500 or 2500 Pounds Pressure

Even when operating pressures on steel valves were limited years ago, Powell Valves were the accepted standard because of their economy in operation. Today, with pressures as high as 2500 pounds at 900 deg. F., Powell Valves are still the choice of "economy - wise" engineers.

Fig. 4061 Swing Check Valve

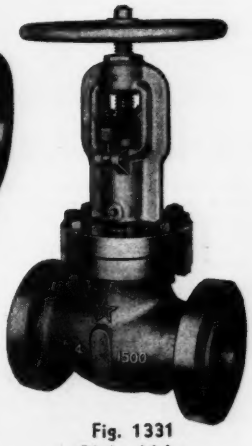
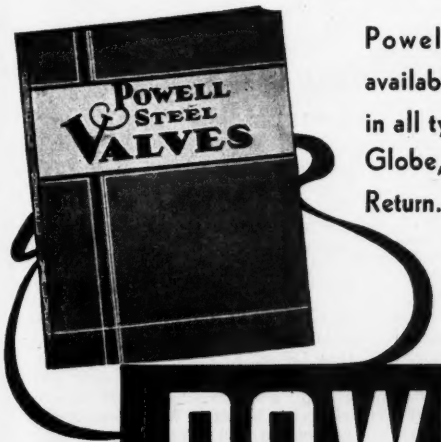


Fig. 1331 Globe Valve



Powell Steel Valves are available from alloy steels in all types and sizes—Gate, Globe, Angle, Check, Non-Return.

Write for Catalog No. 101

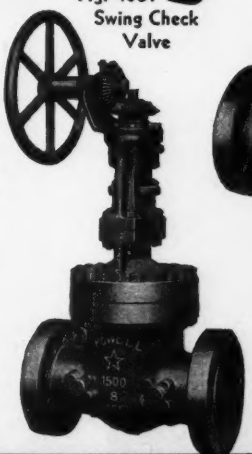


Fig. 1303 Gate Valve with Bevel Gears

POWELL VALVES

THE WM. POWELL CO. CINCINNATI, OHIO

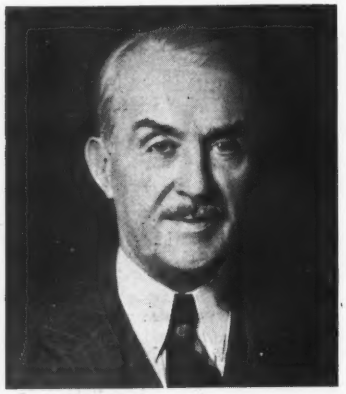
nected with the Sullivan Machinery Co., having joined the organization in 1913. In the 21 yr. which followed, he worked successively as apprentice in each plant, serviceman in the mines, salesman, export manager, vice president and controller. He has been a director of the Company since 1923. In 1934 he left to become President of the H. Channon Co.

The election of Mr. Copeland to the presidency of the Sullivan Machinery Co. has additional historical significance to the employees and stockholders, as his father, the late Frederick K. Copeland, served as President of the Company from 1892 to 1928.

H. T. Walsh, J. W. Haddock, W. R. Jarvis and L. T. Noel was the newly elected directors of the Company.

Johns-Manville Corp.

WILLIAM H. FOGARTY, who has been with Johns-Manville 27 yr. in the Company's Chicago office, has been transferred from the Chicago district man-



William H. Fogarty

agership to the power products department to assistant to the vice president of the J-M Sales Corp. but will continue to make his headquarters in Chicago.

Corydon H. Hall

Corydon H. Hall, who succeeds Mr. Fogarty as district manager, is a son of the late Charles C. Hall of Alexandria, Ind., inventor of rock wool and generally credited with launching the home insulation industry in America.

Temperature Symposium Being Planned

TEMPERATURE and Its Measurement in Science and Industry will be the subject of a symposium to be held under the auspices of the American Institute of Physics, 175 Fifth Ave., New York, N. Y., probably next fall, the dates to be announced later. Consistent with the title, the symposium will broadly cover many fields, its primary purposes according to present plans being to coordinate the treatment of the subject in the sciences and branches of engineering, to review principles and bring up to date the record of recent work, to accumulate contributions for a comprehensive text to be published as soon as possible after the symposium is held, to reveal the subject as an important branch of physics, and supply schools with the information required for the improvement of curricula. The Institute confidently expects that a stimulating, valuable and unified program will be arranged, an aim which will require the help of many contributors.

Arrangements are being made by a representative steering committee consisting of the Chairman, C. O. Fairchild, Director of Research, C. J. Tagliabue Mfg. Co.; Dr. E. F. DuBois, Medical Director Russell Sage Institute of Pathology and Professor of Medicine Cornell University Medical College; Dr. Gustav Egloff, Director of Research, Universal Oil Products Co.; Dr. John Johnston, Director of Research, U. S. Steel Corporation; Dr. Walter G. Whitman, Head, Department of Chemical Engineering, Massachusetts Institute of Technology; and Dr. H. A. Barton, Director, American Institute of Physics.

Those who are interested in taking part in this symposium should communicate with the Institute at an early date, giving information regarding their field of work and the subject of the contribution they wish to make. Such contributions will be coordinated with the subjects of a group of invited papers, and assignments and divisions made.

Midwest Power Conference

ARRANGEMENTS are being completed for the second annual Midwest Power Conference under the auspices of the Armour Institute of Technology in cooperation with seven middle western universities. It will be held April 5-7 in Chicago at the Palmer House Hotel. Dr. L. E. Grinter, Dean of the Graduate division and Director of Civil Engineering at Armour Institute is Director of the conference.

The program planned for the conference will include some 25 important subjects discussed by authorities from educational and industrial fields. Emphasis will be placed on steam, Diesel, electric, and hydraulic power. In each of these fields, papers will be presented which will discuss the best modern practice, while other papers will venture into the picture of the future as indicated in the investigations of our great research laboratories.

Of special interest to the conference will be a paper on the social significance of the development of Diesel power. Timely and local in its importance will be a discussion of Chicago's air pollution problem by the director of Chicago's air pollution survey. Papers presenting various phases of the controversial subject of high pressure-high temperature metallurgy are also looked upon with special interest. Railway motive power, rural electrification, power plant statistics, and the achievements of research in power are but a few of the highly interesting subjects to be presented and discussed.

William P. Bradbury

WILLIAM P. BRADBURY, 53, Vice President and General Sales Manager of the Consolidated Ashcroft Hancock Division of Manning, Maxwell & Moore, Inc., Bridgeport, Conn., died of pneumonia after a six-day illness, on Saturday, January 14.

Mr. Bradbury joined Manning, Maxwell & Moore in 1902 as an office boy and advanced step by step through various positions in the sales department. These assignments took him to every part of the United States and some foreign countries. In 1923 he was made general sales manager and in 1930 Vice President in charge of Sales, the position he held until his death. During the past quarter of a century there has scarcely been a public utility or any other major power plant built in which he has not rendered a helpful service. Similarly Mr. Bradbury numbered as his friends hundreds of distributors and their salesmen.

Industrial Gas Activities

D. W. Reeves

D. W. REEVES of the Oklahoma Natural Gas Co., Tulsa, Okla., is the newly appointed Chairman of the Gas Power Committee of the American Gas Association. One of the projects scheduled for completion this year is a sales-engineering handbook for the use of those who sell, service, power, or utilize gas-fueled internal combustion engines. Mr. C. Remschel of the Southern Counties Gas Co., Los Angeles, has already outlined the content of the book and contributed considerable material.

SAE Endurance Sweepstakes

IN A COAST to coast World Fair hookup the SAE will establish a new long distance endurance convention record. The 1939 World Automotive Engineering Congress of the SAE will begin at the Hotel Pennsylvania, New York City, on May 22 and wind up at Hotel Farmont, San Francisco, June 8. The program includes four big dinners and 90 technical sessions covering every professional division of the Society so that Diesel Engines will occupy an important place in the program. Fifteen foreign governments and 30 foreign engineering societies have been invited to participate and many have already appointed official delegates. The complete western circle tour (excluding meals in New York and banquet tickets) will cost approximately $360. For those who cannot make the complete trip, a circle tour as far west as Chicago has been arranged and will cost approximately $175.

Top-Quality JENKINS iron VALVES

cut maintenance!

THIS 30-inch Jenkins Iron Valve shown, serves on main steam line at New York's famous 40 story Equitable Building.

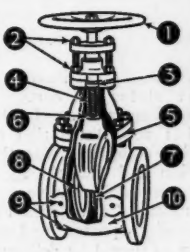
It isn't size alone that makes a valve big—but the way it's made and the way it has performed. Chief Engineer Paulsen's records show that maintenance on this Inside Screw Gate has been practically zero, since it was installed 25 years ago.

When you get Jenkins top-quality, at standard prices, there's no reason why your plant can't have this same iron valve economy. Check over the outstanding plus values we've spotted in the diagram at right. They are typical of the dollars and cents reasons for buying a Jenkins Iron Body Valve every time.

JENKINS BROS., 80 White St., New York, N.Y.; Bridgeport, Conn.; Boston, Mass.; Atlanta, Ga.; Philadelphia, Pa.; Chicago, Ill.; Houston, Texas; Montreal, Canada; London, England

1864 JENKINS TRADE MARK 1939
DIAMOND Jenkins Bros ANNIVERSARY

PLUS FEATURES OF THIS I. S. GATE



1 Handy-Grip Wheel
2 Time-Saving Bolts
3 Liberal Thrust Collar
4 Bronze Wedge-Bushing
5 Long-Life Asbestos Gasket
6 Extra Strength Spindle
7 Self-Aligning Wedge Guides
8 Renewable Bronze Seat Rings
9 Six Convenient Bosses
10 Iron *Exceeds* A.S.T.M. Standards

Guide to Figure Numbers of Jenkins Inside Screw Iron Body Gate Valves

PRESSURE	SOLID WEDGE		DOUBLE DISC	
	SCW.	FLG.	SCW.	FLG.
125 Lbs. W.S.P.	325	326	872	873
175 Lbs. W.S.P.	251	255	—	—
250 Lbs. W.S.P.	203A	203	876	877

A.I.E.E. Nominations

THE NATIONAL NOMINATING COMMITTEE of the American Institute of Electrical Engineers, consisting of members from various parts of the country, has nominated the following official ticket of candidates for the offices becoming vacant August 1, 1939:

For President: F. Malcolm Farmer, Vice-President and Chief Engineer, Electrical Testing Laboratories, New York, N. Y.

For Vice-Presidents: (Middle Eastern District) C. T. Sinclair, Electrical Engineer, Transmission and Distribution, Duquesne Light Company, Pittsburgh, Pa. (Southern District) E. E. George, Superintendent of System Operation, Tennessee Electric Power Company, Chattanooga, Tenn. (North Central District) Albert L. Turner, Chief Engineer, Northwestern Bell Telephone Company, Omaha, Nebraska. (Pacific District) H. W. Hitchcock, Chief Engineer, Southern California Telephone Company, Los Angeles, Calif. (Canadian District) J. M. Thompson, Chief Designing Engineer, Ferranti Electric, Ltd., Toronto, Ont., Canada.

For Directors: Mark Eldredge, Chief Engineer, Memphis Power & Light Company, Memphis, Tenn. R. E. Hellmund, Chief Engineer, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa. Frank J. Meyer, Vice-President in charge of Operation, Oklahoma Gas & Electric Company, Oklahoma City, Okla.

For National Treasurer: W. I. Slichter, Professor of Electrical Engineering and Head of Department, Columbia University, New York, N. Y.

These official candidates, together with any independent nominees that may be proposed later in the manner specified by the Constitution and By-laws, will be voted upon by the membership at the coming election this spring.

TVA Wins Court Dicision

ON JANUARY 30 the United States Supreme Court handed down another decision on the controversy between the Tennessee Valley Authority and 14 utilities that are endeavoring to find their exact status in competition with the government agency. In the opinion rendered it was stated that the pith of the specific complaint was the TVA's competition and that the appellants realized that competition between natural persons is lawful. "They seek to stigmatize the Authority's present and proposed competition as illegal by reliance on their franchises which they say are property protected from injury or destruction by competition. The vice of the position is that neither their charters nor their local franchises involve the grant of a monopoly or render competition illegal.

"If the thesis were sound, appellants could enjoin a competing corporation or agency on the ground that its injurious competition is ultra vices, that there is a defect in the grant of powers to it, or that the means of competition were acquired by some violation of the constitution.

"The contention is foreclosed by prior decisions that the damage consequent on competition, otherwise unlawful, is in such circumstances damnum absque injuria, and will not support a cause of action or right to sue."

For the Engineer's Library

Any Catalogs that you wish will be gladly sent. Write Power Plant Engineering.

Valves and Piping

Controlled Valves, an illustrated 27-pp. bulletin 214-1 on two widely used types of air-operated controlled valves, the quick-opening type for open and shut control, and the Stabilflo type for throttling control. Detailed information about these two types of valves is contained in specification charts, power curves, pressure-temperature ratings and valve formulas. For engineers who must frequently compute valve sizes, the company is offering a new pocket-size slide rule with scales for liquid, gas and steam calculations, direct-reading in valve sizes. This 6-in. valve rule, in a leather case, will be sent free to engineers who request it on their business letterhead. The Foxboro Co., Foxboro, Mass.

Reseater—This bulletin discusses a set of tools which restores any valve to its full efficiency by tapping a thread into the old seat metal and screwing in a new renewable seat. The Standard Reseater can be used on any globe valve, faucet, radiator valve, concealed fitting, ballcock, vacuum trap or flushometer, barring seat orifices from as small as ¼ to as large as 1½ in. Standard Reseater Corp., 423 W. 126th St., New York, N. Y.

Fittings—A booklet of catalog proportions entitled "New and Better Fittings for Small Welded Lines" has just been issued to introduce a new product. The product and its uses are graphically portrayed with photographs and drawings. Tables are presented showing the hydrostatic bursting pressures, tensile pull tests and working pressures. Numerous drawings provide detailed measurements of the fittings. Crane Co., 836 South Michigan Ave., Chicago, Ill.

Valves—Three new circulars have just been released. The Valves Invincible is the title of one describing 150 lb. WSP bronze gate valves. Another under the title Towers of Strength for any line describes 125 lb. WSP bronze gate valves. The third circular describes the Duo-Bolt gate valves. The Ohio Injector Co., Wadsworth, Ohio.

Stainless Steel Bellows Expansion Joint—The Type S stainless steel bellows, packless expansion joints built in 50, 150 and 300 and 600 lb. series in standard sizes from 2 to 36 in. are described in a four-page bulletin No. X-39-5. Foster Wheeler Corp., 165 Broadway, New York, N. Y.

Electrical Equipment

Indoor Disconnecting Switch and Fuse Mountings—A 32-page Bulletin 33-B, under this title describes Hook-Operated disconnecting switches from 500 v. to 5000 v., also from 7.5 kv. to 34.5 kv. Group Operated Switches are also described giving operating mechanisms and specifications. A part of the bulletin is devoted to a discussion of fuse mounting and accessories. Bulletin 38-D issued by the same company is entitled Bus & Cable Connectors. It has 168 pages and gives a complete discussion of the subject and general engineering information. Four pages in front of the book are devoted to a pictorial index of the equipment that is treated. Delta Star Electric Co., 2400 Fulton St., Chicago, Ill.

Motor Application Chart—This chart lists 26 different types of motors and checks the proper type of motor recommended for about 50 standard applications. It also analyzes the starting, maximum and full load torque characteristics of these motors; speed regulation; per cent of slip and a wealth of other valuable information compiled for ready reference. Ask for copy of bulletin No. 515 and address the Advertising Department of The Louis Allis Co., Milwaukee, Wis.

Motors—Bulletin 610 is a condensed 8-page booklet including general information on NEMA Standards and Definitions. This booklet includes suggestions for the proper selection of motors, types of drives, various types of protected motors and their definitions; information regarding service factors, rated loads, torques and other important reference information. The Louis Allis Co., Milwaukee, Wis.

Motors—A new simplified motor price list and Catalog No. 39 contains useful price information and application data on motors, generators, motor-generator sets, ventilating equipment, grinders, etc., with all of the material arranged in simplified form for quick and easy reference. Diehl Mfg. Co., Elizabethport, N. J.

Rectifiers—A new illustrated leaflet No. 2343 covers the small capacity, permanently evacuated, glass bulb rectifier units recently put on the market by the company. It deals with many advantages inherent in such equipment for use in small traction systems, industrial plants with moderate direct current power requirements, and large buildings affected by d.c. to a.c. changeovers. In addition to comparative efficiency curves, this eight-page leaflet includes typical wiring diagrams. Allis-Chalmers Mfg. Co., Milwaukee, Wis.

READING-PRATT & CADY VALVES

Specified for these important installations

MORE WHO *SPECIFIED* R-P. & C. VALVES

Water Works: Just completed, valves from 2″ to 20″. All valves that were installed were specified Reading-Pratt & Cady.

Municipal Building: A $3,000,000 building in course of erection. All valves specified Reading-Pratt & Cady.

Packing House: Now completed. All valves for all purposes specified Reading-Pratt & Cady.

Steam Power Plants: In 1938 more than ever before specified Reading-Pratt & Cady valves for high pressure and high temperature service.

Chemical and Allied Industries: In 1938, more oil companies, textile mills, paper mills specified Reading-Pratt & Cady valves—many with special alloys and trim required to meet their specific needs.

You, also, will find it worth while to get Reading-Pratt & Cady recommendations for your valves. You will find them sound. You can depend on them.

In this way you, too, can make certain that the valves are *right* for your service . . .

● The engineer on a newly completed project said: "We *specified* Reading-Pratt & Cady valves throughout because we knew that each one recommended by the Reading-Pratt & Cady engineers would meet the demands to be made of that valve."

READING-PRATT & CADY DIVISION • BRIDGEPORT, CONNECTICUT

AMERICAN CHAIN & CABLE COMPANY, Inc.

AMERICAN CHAIN DIVISION • AMERICAN CABLE DIVISION • ANDREW C. CAMPBELL DIVISION • FORD CHAIN BLOCK DIVISION • HAZARD WIRE ROPE DIVISION • HIGHLAND IRON AND STEEL DIVISION • MANLEY MANUFACTURING DIVISION • OWEN SILENT SPRING COMPANY, INC. • PAGE STEEL AND WIRE DIVISION • READING-PRATT & CADY DIVISION • READING STEEL CASTING DIVISION • WRIGHT MANUFACTURING DIVISION • IN CANADA: DOMINION CHAIN COMPANY, LTD. • IN ENGLAND: BRITISH WIRE PRODUCTS, LTD. • THE PARSONS CHAIN COMPANY, LTD. • *In Business for Your Safety*

Metals

Welding of Wrought Iron is the title of a revised bulletin which was first presented early in 1934. Tests have since been run by the National Weld Test Bureau, Lloyd's Register of Shipping, American Bureau of Shipping, and the Bureau of Marine Inspection and Navigation. In addition considerable practical information has been obtained from the field. All this has been incorporated in the new bulletin. A. M. Byers Co., Pittsburgh, Pa.

Investigation of Creep and Fracture of Lead and Lead Alloys for Cable Sheathing, by Herbert F. Moore, Bernard B. Betty and Curtis W. Dollins is the title of a report of an investigation conducted by the Engineering Experiment Station, University of Illinois, in cooperation with the Utilities Research Commission. The bulletin number is 102 and the price $1.00 but a limited number of copies are available for free distribution by the Engineering Experiment Station. The University of Illinois, Urbana, Ill.

Digest of Properties, Carbon and Alloy Steel Tubing for High-Temperature—High-Pressure Service is the title of Technical Bulletin 6-C which is a complete revision and enlargement of previous editions, now covering the general field of high-temperature applications. All data are summarized in tables, with detailed explanations to make them more readily understandable. The Babcock & Wilcox Tube Co., Beaver Falls, Pa.

Feedwater Heater—The Swartwout deaerating feedwater heater is illustrated and described in Bulletin S-18-D just issued by The Swartwout Co., Cleveland, Ohio.

Power Transmission

Gearmotor—A new leaflet 2203-B on compact self-contained gearmotor speed reducers for efficient low-speed operation, presents numerous line drawings and installation photographs showing typical gearmotor applications. It includes a table of ratings and speeds with 1750 r.p.m. motors. Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Geared Drives for Industries—A new booklet explaining the uses, adaptations and developments of all types of geared drives has just been announced. Single, double and triple reduction gearmotors; single and double reduction speed reducers; special vertical and right angle vertical geared drives; single and double reduction heavy duty mill units; horizontal speed reducers with shafts in vertical plane; geared drives for special problems and conditions; and open gearing are discussed. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Car Pullers, Hoists and Winches is the title of an 8-page, two-color catalog which gives specifications, dimensions and required engineering information on how to select power car pullers. Stephens-Adamson Mfg. Co., Aurora, Ill.

Speed Reducers — Westinghouse Types SH and DH speed reducers, used with all prime movers such as electric motors and gas, oil or Diesel engines, and suitable for any application where economy of power transmission and exact speed reduction are important, are extensively described in an illustrated booklet, Descriptive Data 3620. Westinghouse gearmotors, self-contained drives consisting of high speed Westinghouse motor and necessary speed reducing unit, are illustrated and discussed in a booklet, Descriptive Data 3610. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Fuel Oil

Motor Fuel Economy of Europe is a paper presented by Dr. Gustav Egloff at the A.C.S. meeting in Milwaukee, and reprinted by the Committee on Motor Fuels of the American Petroleum Institute, 50 W. 50th Street, New York, where copies are available to those interested. During 1937 Europe satisfied 18 per cent of its motor fuel requirements with various substitutes including alcohol, compressed gas and combustibles produced from wood and charcoal.

Pumps—Rotary displacement pumps for handling fuel and crude oils, lubricating oils and hydraulic oil are described in Catalog L-31. De Laval Steam Turbine Co., Trenton, N. J.

Coal and Ash Handling Equipment

Stokers—A booklet B-2170 describing single and multiple retort stokers, designed to meet every bituminous coal burning requirement in industry, has recently been published. Included are multiple retort stokers for boilers from 300 rated b.hp. up, of four types, continuous ash discharge stokers with link-grate action, clinker-grinder stokers with link-grate action, dump grate stokers with agitator, dump grate stokers; and single retort stokers for boilers from 100 to 500 rated b.hp., in moving or stationary grate types. Westinghouse Electric & Mfg. Co., East Pitts-

Coal and Ash Handling Equipment—A new bulletin 331, entitled How to Handle It With Rex Coal and Ash Handling Equipment contains many pictures of present Rex coal handling installations together with drawings of typical uses of Rex power plant equipment. Chain Belt Co., Milwaukee, Wis.

Air Compressors

A Safety Code For Compressed Air Machinery and Equipment, sponsored by the A.S.M.E., has been completed and approved by the A.S.A. The Code covers equipment construction, application and installation and has been developed from the combined experience of manufacturer, user, insurance and government groups. It covers 9 pp. and copies can be obtained for 30 cents each from either the American Standards Association or the American Society of Mechanical Engineers, both at 29 West 39th Street, New York city. burgh, Pa.

Air Compressors—New 16-page catalog describing advanced design air and gas compressors known as the Class WN-112, illustrates a variety of industrial installations. This compressor is built in sizes from 378 to 1600 cu. ft. per min. displacement (60 to 250 hp.) for commercial pressures. Copies may be had by writing for Bulletin A-18 to Sullivan Machinery Co., Michigan City, Indiana.

Public Relations

Public Relations—A chart showing the factors in relations of an organization to Labor, Consumer, Industry, the Community and Investors, with analysis of the studies to be made recommendations to be determined from these studies and methods of carrying out rcommendations has been compiled by Haworth, Powell & Thomas, 30 Rockefeller Plaza, New York city. Topics taken up are Wages, Benefits Plant Condition, Labor Laws, Union Relations, Market for the Product, Merchandising and Promotion, Cultivating Public Good Opinion, Relations with Stockholders. The chart is designed to give a better understanding of the essential factors in establishing good public relations. Copies may be had, without charge, by writing to Haworth, Powell & Thomas.

The Importance of Scientific Research and the part it has played in research by the Federal Government was emphasized in a report made by the Science Committee of the National Resources Committee and transmitted to Congress by the President during the latter part of January. It is the first of a series of reports on this field and is entitled "Research—A National Resource—Part I.—Relation of the Federal Government to Research" and can be obtained from the Superintendent of Documents, Washington, D. C., for 50 cents. The report trimmed to 9 by 12 size and consists of 265 pp.

Miscellaneous

Miscellaneous Conversion factors, a scale for converting Fahrenheit to Centigrade degrees, temperature corrections for the Brix scale and capacities of vertical cylindrical tanks are included on a new 2 by 8 in. heavy celluloid scale which will be sent to engineers upon request to Graver Tank & Mfg. Co., Inc., East Chicago, Ind.

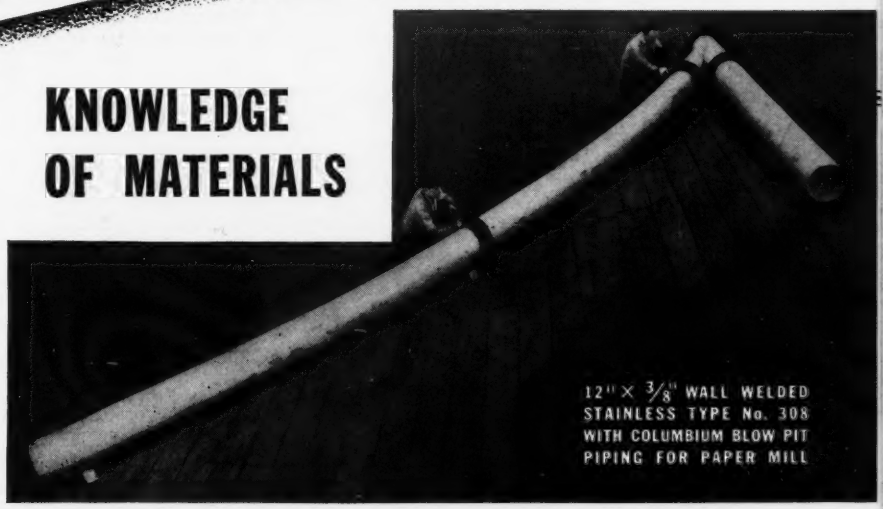
The Made-Rite Boiler Tube Plug is illustrated and described in a new 12-page pocket size booklet just issued by Hardie Made-Rite Boiler Tube Plug Co., 1245 Madison Ave., New York, N. Y.

Bench Grinder—Diehl DeLuxe Heavy Duty type bench grinder is illustrated and described in Bulletin No. 1932. Diehl Mfg. Co., Eliabethport, N. J.

Steam Drive Power—A turbine Westinghouse Type M, in the 100 to 2000 hp. range, manufactured for every type of industry using mechanical and electrical power, is described in a new booklet, 22 double pages, just released. These turbines are for 1000 to 5500 r.p.m., for steam pressures up to 650 lb., steam temperatures to 750 deg. F., exhaust pressures from 200 lb., to 29 in. Hg. vacuum and extraction pressures to 200 lb. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

ON ALL KINDS OF POWER and PROCESS PIPING, MAKE USE OF THESE PITTSBURGH PIPING "PLUS VALUES"

KNOWLEDGE OF MATERIALS



12" × 3/8" WALL WELDED STAINLESS TYPE No. 308 WITH COLUMBIUM BLOW PIT PIPING FOR PAPER MILL

Whether it's carbon-moly, plain carbon steel, cast iron or stainless steel piping that will best suit your particular piping requirements, you can trust its fabrication to Pittsburgh Piping secure in the knowledge that we know from actual experience how each particular metal is best handled. Because of the peculiar characteristics of stainless steel, a separate Alloy Division was formed in 1933 to fabricate stainless piping and vessels. Such specialization means better fabrication at lower cost.

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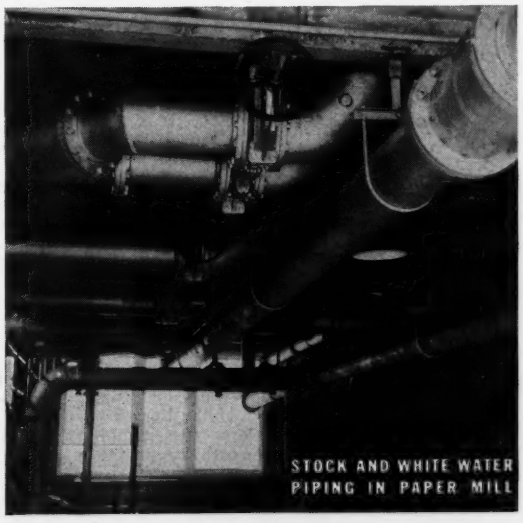
SAFETY VALVE MANIFOLD FOR FOUR 6" SAFETY VALVES 150# TURBINE EXHAUST LINE

The accurate pre-fabrication of large sub-assemblies, under controlled conditions, such as this steam exhaust piping for a prominent chemical plant, makes possible more efficient design of the piping system and saves fabrication and erection time. Pittsburgh Piping has adequate shop equipment and skilled men for precision work of this type.

SPEEDY ERECTION

Whether you are contemplating an entirely new plant or an addition to your present power or process piping, you will appreciate the ability of experienced Pittsburgh Piping field erectors to work on schedule without interfering with other sub-contractors or without affecting the operation of existing portions of your plant.



STOCK AND WHITE WATER PIPING IN PAPER MILL

PITTSBURGH PIPING AND EQUIPMENT COMPANY
10 FORTY-THIRD STREET **PITTSBURGH, PENNA.**
Branch Offices in Principal Cities

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Power Plant Construction News

Ala., Mobile—Hollingsworth & Whitney Co., 140 Federal Street, Boston, Mass., plans power house at new pulp and paper mill on waterfront property at Mobile. Electric power equipment will be installed for mill service. Plant will comprise several large production units, estimated to cost approximately $5,000,000. Work will be placed under way this spring.

Ark., Hot Springs—Arkansas Power & Light Co., Pine Bluff, Ark., has plans maturing for new hydroelectric power development in vicinity of Blakeley Mountain, near Hot Springs, consisting of power dam, flood control basin, generating station, and transmission lines for connection with present high-tension system. Project reported to cost close to $7,500,000.

Calif., Antioch—State Water Project Authority, Sacramento, Calif., is considering construction of a state-owned hydroelectric generating station in vicinity of Antioch, to tie-in with Shasta, Calif., power development of Federal Government, known as Central Valley Project. Proposed state plant is reported to cost in excess of $5,000,000, with transmission lines, switching stations and other operating facilities.

Calif., Los Angeles—Coca-Cola Co., 963 East Fourth Street, plans installation of electric power equipment in new three-story and basement addition to local beverage and bottling plant, including improvements in present unit. Entire project will cost close to $200,000. Work is scheduled to begin soon. W. P. Weisiger is company engineer, address noted.

Conn., Hartford—Pratt & Whitney Division, Niles-Bement-Pond Co., Capitol Avenue, Hartford, plans installation of electric power equipment in new machine tool and small tool-manufacturing works at West Hartford, where company has a large tract of land. Initial unit will total about 700,000 sq. ft. of floor space. A power house will be built. Entire project estimated to cost over $1,700,000.

Ill., Decatur—Archer-Daniels-Midland Co., 109 South Seventh Street, Minneapolis, Minn., linseed oil products, plans steam power house at new soybean processing mill at Decatur, where site was recently acquired. Power equipment will be installed for mill service. Entire project will cost in excess of $1,200,000.

Ind., Hammond—Municipal Sanitary District, City Hall, Joseph E. Haney, president, plans large pumping station in connection with extensions in sewage system, and will take bids for pumping machinery and auxiliary equipment late in spring. Fund of about $220,000 has been arranged for entire project. Clarence A. Mason, City Hall, is city engineer; Charles Hurd, Calumet Theater Building, Hammond, is consulting engineer.

Ind., Indianapolis—RCA Mfg. Co., 501 North LaSalle Street, plans installation of electric power equipment in new one-story addition to radio apparatus manufacturing plant. Cost reported over $200,000. Albert Kahn, Inc., New Center Building, Detroit, Mich., is architect and engineer. Main office of company is at 411 Fifth Avenue, New York, N. Y. H. E. LeRoy is plant manager at Indianapolis.

Mich., Marquette—City Council plans extensions and improvements in municipal hydroelectric power plant, including installation of equipment. Cost estimated close to $180,000. Holland, Ackerman & Holland, Ann Arbor, Mich., are consulting engineers.

Iowa, Cedar Rapids—Penick & Ford Co., First Street and Tenth Avenue, S. W., manufacturer of food products, plans installation of electric power equipment in new three-story and basement addition to local plant, to be equipped for processing service. Entire project will cost over $100,000. Main offices of company are at 420 Lexington Avenue, New York, N. Y.

Iowa, Chariton—City Council plans early purchase of local power plant of Peoples Gas & Power Co., and will operate as municipal property in future. Extensions and improvements will be made in station, including installation of additional equipment. Bond issue of $98,000 is being arranged for project. John A. Olson, city clerk. N. W. Cloud, mayor, is active in program.

Iowa, Des Moines—Swift & Co., Oil Mill Division, Union Stock Yards, Chicago, Ill., plans installation of electric power equipment in new soybean processing mill at Des Moines, where site has just been acquired at Delaware and East Euclid Avenues. A boiler house will be built. Entire project will cost close to $300,000. Company engineering department will be in charge. Proposed to begin work soon.

Kan., Kansas City—Agar Mfg. Corporation, Thomas Street, Whippany, N. J., plans steam power house, 40x60 ft. at new corrugated box-manufacturing plant at Kansas City where site has been acquired. Electric power equipment will be installed for mill service. Entire project will cost close to $125,000. Proposed to begin work soon.

Kan., Kansas City—Board of Public Utilities Commissioners, City Hall, plans large pumping station for water system service. Cost close to $500,000 with pumping machinery and auxiliary equipment, including connecting pipe lines. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

Ky., Frankfort—State Board of Education, Frankfort, has plans maturing and will take bids soon for new power plant at local State Industrial College. Cost reported over $75,000. Leo Oberwarth & Sons, West Second Street, Frankfort, are architects.

Md., Towson—Julien P. Friez & Sons, Division of Bendix Aviation Corporation, 4 North Central Avenue, Baltimore, manufacturers of hydrometric, air-conditioning and other weather-measuring instruments, plan installation of electric power equipment in new branch works on Joppa Road, Towson, near Baltimore, where tract of 18 acres of land has been purchased. Initial unit will be 80x400 ft., with wing extension, 100x100 ft. Entire project will cost about $500,000.

Mich., Ann Arbor—King-Seeley Corporation, Detroit Street, manufacturer of oil pumps, gauges, etc., plans installation of electric power equipment in new addition to plant. Entire project will cost about $100,000. Giffels & Vallet Inc., Marquette Building, Detroit, Mich., is architect and engineer.

Minn., Madison—City Council has plans nearing completion for expansion and modernization of municipal electric power plant, and will take bids soon. Work will include installation of a new 3500-kw. Diesel engine-generator unit and auxiliary equipment. Cost about $182,700. Financing has been arranged through Federal aid. Perkins & McWayne, Paulton Block, Sioux Falls, S. D., are consulting engineers.

Neb., Lincoln—Lincoln Co-operative Milk Producers' Association, First National Bank Building, George E. Hazer, director, plans installation of electric power equipment in new milk-processing plant in vicinity of South Street, where site has been selected. Proposed to build a boiler house. Entire project will cost close to $100,000.

N. Y., Little Falls—City Council has tentative plans under consideration for new municipal electric power plant. Cost estimated close to $150,000. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

Ohio, New Philadelphia—City Council is projecting plans for a municipal electric light and power plant, and will have estimates of cost made at early date.

Ohio, Toronto—Ohio Edison Co., Akron, Ohio, has plans maturing for expansion and improvements in steam-electric generating station at Toronto, including installation of new 35,000-kw. turbo-generator unit, boilers and auxiliary equipment. Cost reported over $1,750,000, including extensions in transmission lines. Proposed to begin work in spring.

Okla., Wagoner—Verdigris River Hydro-Electric, Inc., care of Carl Matthews, Catoosa, Okla., head, is planning new hydroelectric generating plant on the Verdigris River, vicinity of Wagoner. Project will include a power dam 4000 ft. long and 75 ft. high, and generating station with initial capacity of about 10,000-kw. A transmission line will be built. Entire project will cost close to $2,000,000.

Texas, Dallas—Kreohler Mfg. Co., Naperville, Ill., plans installation of electric power equipment in new furniture-manufacturing plant at Dallas, where site is being secured. Proposed to build a boiler house. Entire project will cost over $200,000. Company is now operating a branch at 2625 Elm Street, Dallas. J. O. Taylor, first noted address, is company engineer.

Wash., Spokane—Washington Water Power Co., has authorized a fund of about $1,400,000 for expansion and improvements in power plants and system during 1939, including installation of additional equipment in hydroelectric stations, power substations, transmission and distributing lines. Work is scheduled to begin soon.